THE

JOHN MURRAY EXPEDITION

1933–34

V

BRITISH MUSEUM (NATURAL HISTORY)

THE

JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME V

ZOOLOGY

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

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B. Quaritch, Ltd., 11, Grafton Street, New Bond Street, London, W.1.; The Sales Offices of H.M. Stationery Office, York House, Kingsway, London, W.C.2; 13a, Castle Street, Edinburgh, 2; 39, King Street, Manchester, 2; 1, St. Andrew's Crescent, Cardiff

AND AT

The British Museum (Natural History), Cromwell Road, London, S.W.7

1937—1939

Made and printed in Great Britain.

Adlard & Son, Bartholomew Press, Dorking, Surrey.

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VOLUME V, No. 1

PHYLLIRHOIDÆ

BY

H. G. STUBBINGS, B.A. (CANTAB.), B.SC. (LOND.)
(Late Scholar of St. Catharine's College, Cambridge)

WITH FIVE TEXT-FIGURES

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B. QUARITCH, LTD., 11 GRAFTON STREET, NEW BOND STREET, LONDON, W.1; DULAU & CO., LTD., 29 DOVER STREET, LONDON, W.1; OXFORD UNIVERSITY PRESS, WARWICK SQUARE, LONDON, E.C.4;
H.M. STATIONERY OFFICE, LONDON, S.W.1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
1937

Price Two Shillings

[*Issued 27th November, 1937*]

DESIGNED AND
PRINTED
BY
ADLARD & SON, LTD.
21, HART STREET, W.C.
AT
BARTHOLOMEW PRESS
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WITH FIVE TEXT-FIGURES.

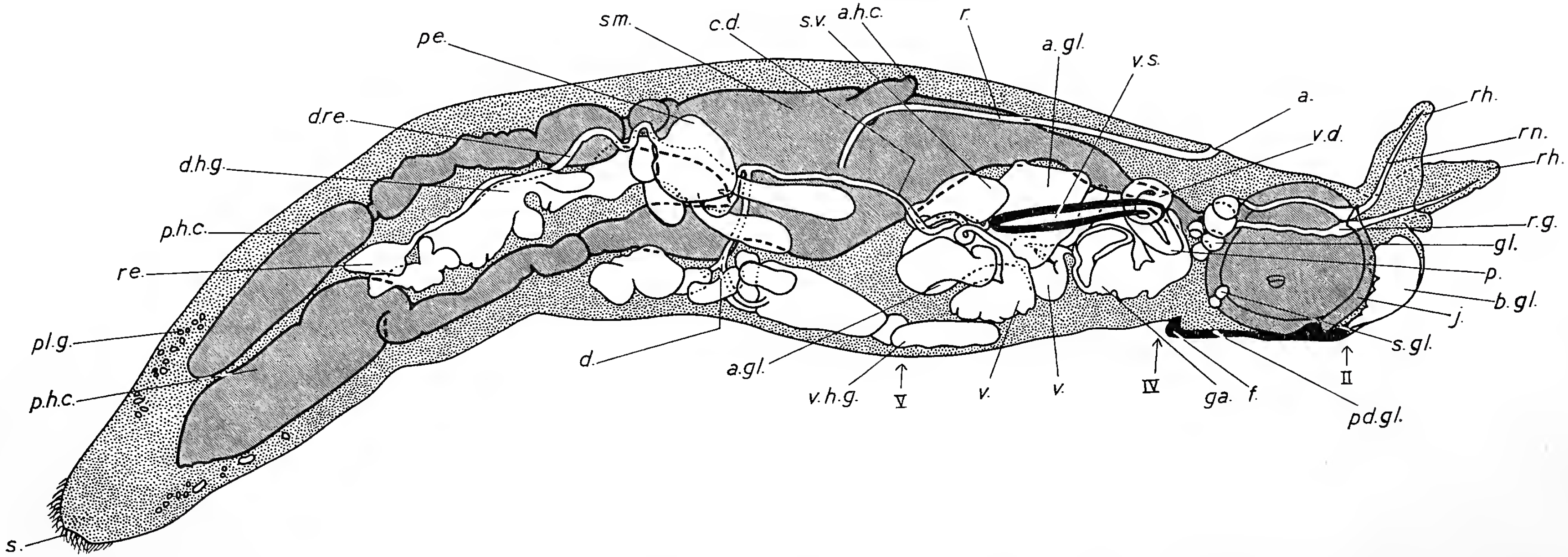
THE Phyllirhoidæ of the "John Murray" Expedition are few in number and represent a new species of the genus *Cephalopyge*. As this species incorporates characters hitherto regarded as diagnostic of one or the other of the two subgenera of *Cephalopyge* recognized by Thiele (1931, p. 446), the systematic grouping of the several species is here discussed and revised. This is particularly necessary, as many previous workers in this field appear to have overlooked considerable portions of the literature. For this reason, also, I have given a full synonymy and references for each species, and as full a bibliography as possible of those works dealing more or less directly with the genus *Cephalopyge* as at present defined.

Cephalopyge arabica sp. nov.

OCCURRENCE.—(i) Sta. 96, Central part of Arabian Sea, 10 metres, 4 specimens.
(ii) Sta. 131 D, Southern Area of Arabian Sea, 500–0 metres, 1 specimen.

DESCRIPTION.—The animal is elongated and laterally compressed. The tail is long and rounded posteriorly and bears a terminal fringe of short curved setæ. The dimensions of one of the largest specimens are as follows: length 5·6 mm., greatest depth 1·2 mm., width 0·4 mm., length of rhinophores 0·6 mm. These dimensions are somewhat smaller than those of the majority of examples of species of *Cephalopyge* described by previous authors. Pierantoni (1923, p. 84) gives 15–17 mm. as the length of *Boopsis mediterranea*, considerably more than that given by Chun for *Cephalopyge trematoides* (Chun)—7–10 mm.—which I regard as the same species. André on the other hand records a specimen of *Ctilopsis picteti* only 3 mm. long, presumably a young animal. Some of the present specimens may likewise be immature individuals. The appearance of the whole animal is shown in Text-fig. 1.

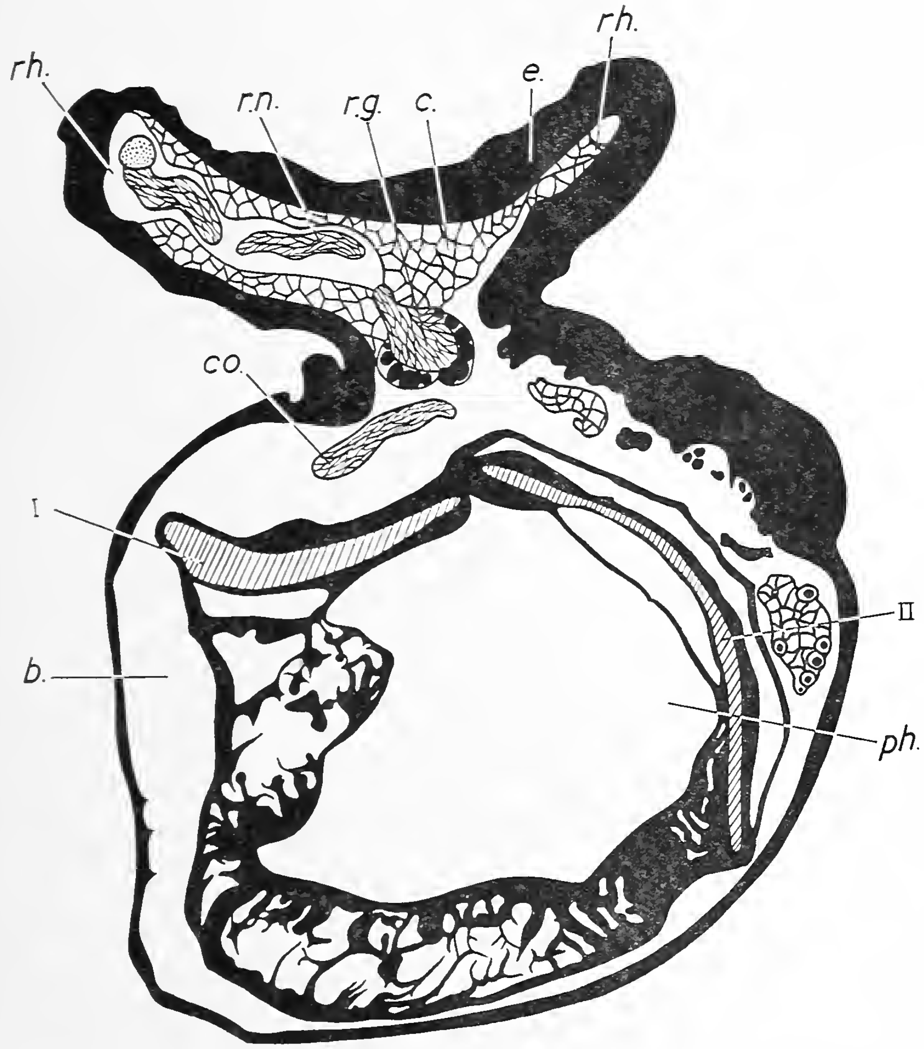
The foot is poorly developed, and projects only slightly beyond the ventral surface of the animal. The pedal gland runs back from the mouth as a narrow deeply-stained track



TEXT-FIG. 1.—*Cephalopyge arabica* sp. nov. Complete animal as drawn from a whole stained preparation with additional details added from sections. *a.*, anus. *a.gl.*, accessory gland. *a.h.c.*, anterior hepatic cæcum. *b.gl.*, buccal glands. *c.d.*, common hermaphrodite duct. *d.*, hermaphrodite duct. *d.h.g.*, dorsal hermaphrodite gland. *d.re.*, duct of renal organ. *f.*, posterior part of foot. *g.a.*, genital atrium. *gl.*, nerve ring. *j.*, jaws. *p.*, penis. *pd.gl.*, pedal gland. *pe.*, pericardium. *p.h.c.*, posterior hepatic cæcum. *pl.g.*, glands in body-wall. *r.*, rectum. *re.*, renal organ. *r.g.*, rhinophore ganglion. *rh.*, rhinophores. *r.n.*, rhinophore nerve. *s.*, setæ. *s.gl.*, salivary glands. *sm.*, stomach. *s.v.*, seminal vesicle. *v.*, vagina. *v.d.*, vas deferens. *v.h.g.*, ventral hermaphrodite gland. *v.s.*, thick-walled part of vas deferens (? sperm-sac). II, IV, V, mark the position of the sections shown in Text-figs. 2, 4, and 5.

as far as the posterior border of the foot, which is indicated by a notch in the outline of the animal.

The rhinophores are stout, laterally-directed, conical projections arising a little behind the extreme anterior end of the animal. They are solid structures with a thick



Text-fig. 2.—*Cephalopyge arabica*. T.S. through the origin of the rhinophores. *b.*, cœlom. *c.*, connective tissue. *co.*, connective between left cerebro-pleural and rhinophore ganglia. *e.*, thick columnar epithelium and musculature of rhinophores and adjacent part of body-wall. *ph.*, pharynx. *r.g.*, rhinophore ganglion. *rh.*, rhinophores. *r.n.*, rhinophore nerve. I, II, left and right jaws.

epidermis overlying a layer of compact, apparently muscular tissue. Within this is a mass of connective tissue, compact peripherally, but somewhat lacunar in the centre. In the compact tissue are numerous deeply-staining round or oval cells apparently similar to the gland-cells described by Pierantoni (1923, p. 86). Up the centre of each rhinophore runs a nerve arising from a ganglion at the base of the rhinophore (Text-fig. 2, *r.n.*).

The structure of the body-wall and connective tissue has been described by Hanel (1905, p. 454) for *C. trematoides* (Chun), André (1906, p. 75) for *Ctilopsis picteti*, and Dakin and Colefax (1936, p. 458) for a species then thought to be probably identical with *Ct. picteti* André (but see Dakin and Colefax, 1937, p. 271). The glands in the body-wall (Text-fig. 1, *pl.g.*) have been exhaustively described by Pierantoni (1923, p. 86) for a species called by him *Boopsis mediterranea*. Similar glands are present in the present species ; they are especially abundant in the posterior third of the body. The epithelium is flattened except on the rhinophores, extreme anterior and posterior ends of the body and the foot, in which regions it is columnar.

The longitudinal muscle-strands agree with the descriptions given by previous authors. The connective tissue is mainly confined to a thin layer in the body-wall, thicker dorsally and ventrally. As Hanel (1905, p. 455) has observed, this tissue forms a thin layer over the digestive and reproductive organs, which it binds together. As mentioned above, it fills the rhinophores. The perivisceral cavity is traversed by a few strands of connective tissue. Behind the accessory reproductive organs (*i. e.* in the posterior two-thirds of the body) there are only two strands of connective tissue traversing the body-cavity horizontally, and so dividing it into three compartments lying in a vertical series. These " partitions " do not seem to have been recorded by previous investigators. The posterior hepatic cæca lie in the upper and lower compartments, and the dorsal hermaphrodite gland and the renal organ in the centre one. I have not observed the " myoblastes " described by André in *Ct. picteti*. Dakin and Colefax (1936, p. 458) also failed to identify these structures.

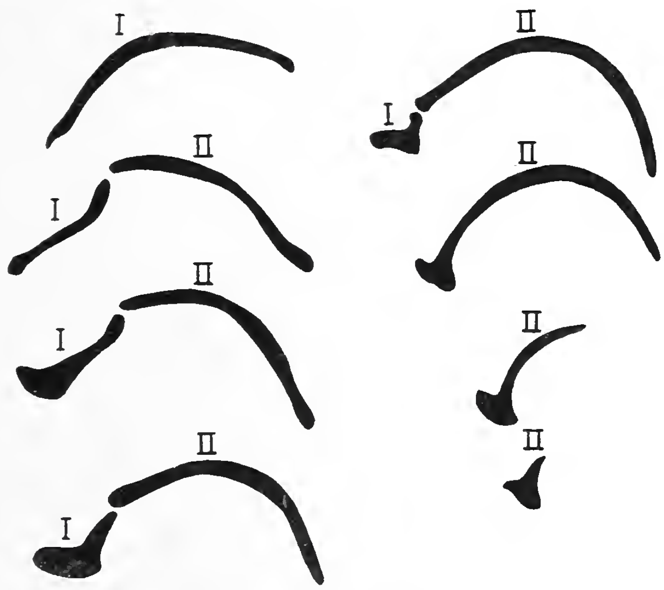
The mouth is anterior or very slightly deflected downwards (*cf. Phyllirhoë* spp., in which the mouth is characteristically antero-ventral). It is surrounded by a glandular area or (in a second specimen) by two lateral, swollen glandular lips. Similar glandular lips in *Boopsis mediterranea* are figured without description by Bertolini (1935, p. 68, fig. 4), and Vessichelli (1906, p. 125, pl. v, figs. 11–13) describes and figures the " glandole boccali " of *Phyllirhoë bucephala*. There does not appear to be a longitudinal ciliated groove on the foot, leading to the mouth, such as Pierantoni describes in *Boopsis mediterranea*.

The salivary glands are extremely small, being represented by two small deeply-staining bodies seen through the pharynx in the whole animal. They were not identified in transverse sections of the animal. André (1906, p. 76) remarks that the salivary glands in *Ct. picteti* are " fortement réduites ".

The pharynx is a large, spherical, thick-walled structure. Its walls are composed of transversely-running muscle-fibres. In the specimen sectioned the pharynx is concave on the left side, with the ganglia of this side lying in the depression. This is most probably an artifact due to contraction during preservation. A curved bar-like structure can be observed, in the whole animal, lying on the anterior periphery of the pharynx. In section this resolves itself into two bars—the jaws—lying side by side. Their appearance in successive transverse sections is shown in Text-fig. 3, I representing the left jaw, II the right. Owing to distortion of the pharynx they have been sectioned somewhat obliquely, which accounts for only one jaw showing in the first and last few sections. The complete jaws probably have a shape similar to that given by Pruvot (1929, p. 468, fig. 2) for *Boopsis mediterranea*. They are devoid of interlocking teeth as in that species.

No trace of a radula can be found in the specimen sectioned, nor is such an organ visible in the stained and mounted specimen. Baba (1933, p. 158) likewise was unable to detect the radula in *Cephalopyge* (*Cephalopyge*) *orientalis*, described and named by him, though he considers that it may have been overlooked, as all the other species then known possessed a radula. Dakin and Colefax (1936, p. 457) were unable to find a radula in their specimens either by dissection or sectioning, though these closely resemble *Ct. picteti* André, for which this author describes and figures a median and a lateral tooth. In a further paper (1937) on the same specimens the absence of the radula is confirmed by Dakin and Colefax, who now regard their specimens as probably identical with *C. orientalis* Baba. Pierantoni (1923, p. 89) described a **T**-shaped structure in the mouth of *Boopsis mediterranea* devoid of teeth. Pruvot (1929, p. 471), however, has shown that this bears a few very small teeth, but adds that there is no trace of a sheath ("gaine").

There are three hepatic cæca, the anterior being very small and little more than a small pouch on the stomach-wall. The rectum is an exceedingly narrow tube opening

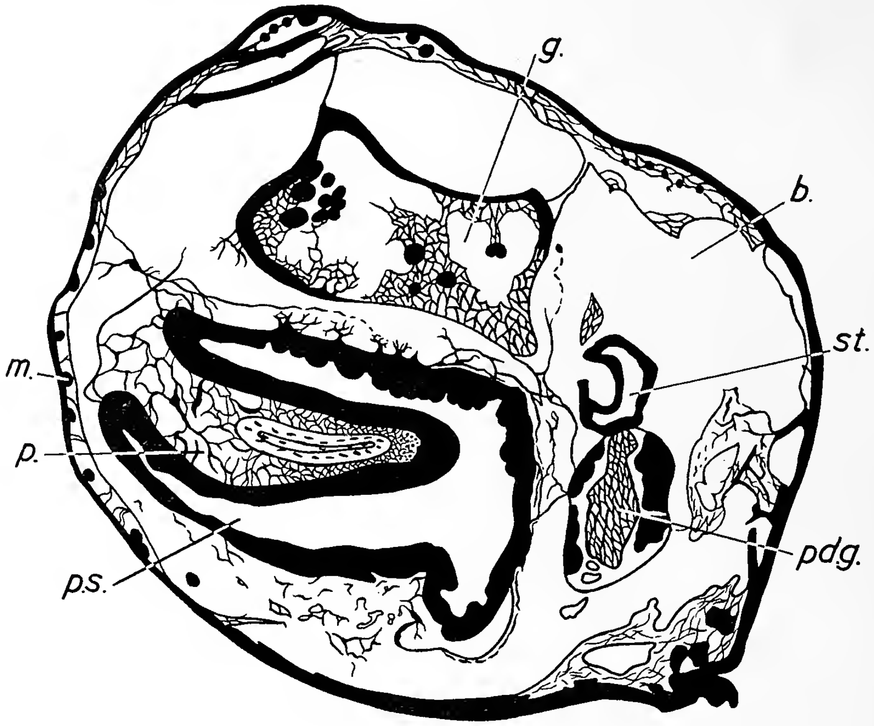


TEXT-FIG. 3.—T.S. through the jaws at successive levels. I, II, left and right jaws.

medianly at the back of the head just behind the nerve-ring. The anus may be raised on a slight projection.

The nervous system (Text-figs. 2, 4) is very similar to that described by André (1906, p. 77), Pierantoni (1923, p. 87) and Dakin and Colefax (1936, p. 458). There is a circum-œsophageal ring of four ganglia; two dorsal cerebro-pleural ganglia lying in contact, and attached to each a lateral pedal ganglion. The pedal ganglia are connected together by a long commissure. From each cerebro-pleural ganglion a nerve runs forwards to a rhinophore ganglion. These ganglia lie close together, and from each a single nerve runs up each rhinophore (Text-figs. 1, 2, *r.n.*). The simple black pigment-spots or "eyes" lie ventrally on the cerebro-pleural ganglia as described and figured by Dakin and Colefax (1936, p. 458, pl. iv, fig. 9). Paired statocysts (Text-fig. 4, *st.*) lie on the nerve-ring at the junction of the pedal and cerebro-pleural ganglia. The stomatogastric ganglia are presumably united by a short commissure as they lie a little apart and not in apposition as described by Dakin and Colefax. Owing to distortion these two ganglia are not both included in any one of the series of sections, and I have been unable to trace this commissure.

The renal organ can be seen in sections as a thin-walled sac arising at the hinder end of the upper hermaphrodite gland and continuing forwards as a narrow duct. In the intact animal it is just possible to make out the duct following a somewhat sinuous course forwards towards the pericardium. It follows the course previously described by authors for other species, running forwards and to the right side and turning upwards at about one-third of the distance from the posterior end of the animal. Here it opens to the exterior by a small pore a little to the right of the mid-dorsal line. The duct then continues forwards between the body-wall and the dorsal posterior hepatic cæcum and enters the pericardium.

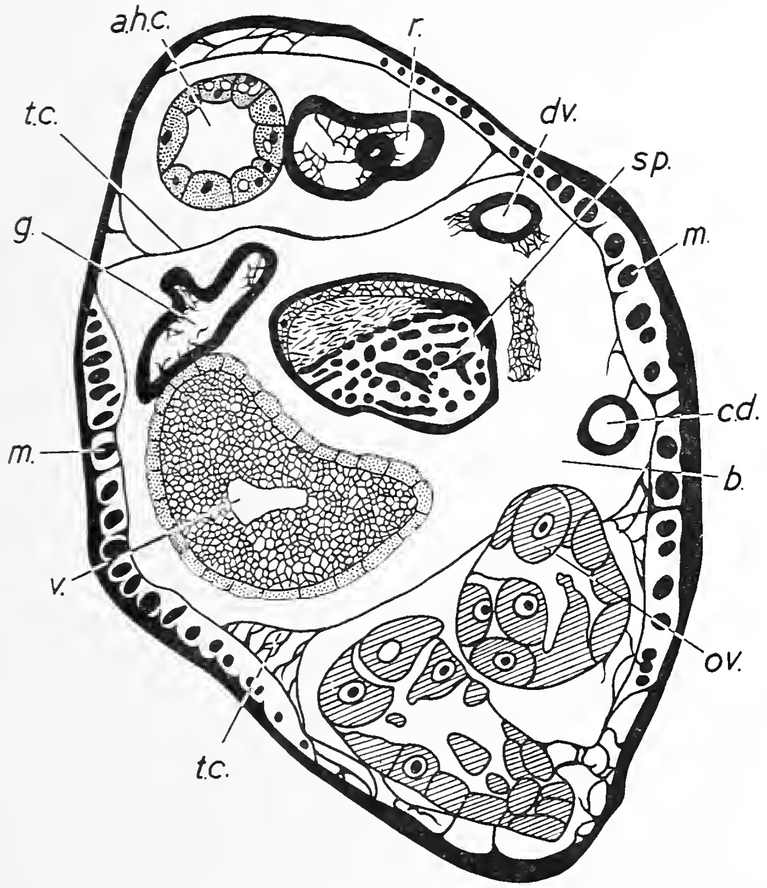


Text-fig. 4.—T.S. through penis, statocyst and right pedal ganglion. *b.*, cœlom. *g.*, gut. *m.*, longitudinal muscles of body-wall. *p.*, penis. *pd.g.*, right pedal ganglion. *p.s.*, penis-sheath. *st.*, statocyst.

The hermaphrodite glands consist of two (or possibly three) horizontal, irregularly-lobed bodies lying in the usual position (Text-figs. 1, *d.h.g.*, *v.h.g.*; 5, *ov.*, *sp.*). The ventral gland is slightly anterior to the other, as in previously-described species. From the ventral hermaphrodite gland two very short ducts arise, one from the anterior portion and the other from the larger posterior portion. They join, and the single duct (Text-figs. 1, *d.*; 5, *c.d.*) runs upwards to meet the duct from the other gland which lies between the hepatic cæca. This duct runs beside the pericardium. The common duct then runs forwards until just anterior to the stomach, where it forks into two. One branch, the vas deferens, continues forwards as a narrow tube which widens almost at once into a thick-walled tube (Text-fig. 1, *v.s.*), possibly the sperm-sac, distinctly visible in the whole animal, and then is joined to the muscular unarmed penis (Text-figs. 1, 4, *p.*) by a short, narrow, coiled duct.

The other branch widens into a small sac, the vesicula seminalis, from which a narrow duct arises, widening out into the large coiled vagina.

Bound up with the vagina are the accessory glands. These appear to be two in number, and are presumably attached to the inner end of the vagina as figured by Pierantoni (1923, pl. iii, fig. 7) for *Boopsis mediterranea* and by Dakin and Colefax (1936, pl. iv, fig. 7) for ? *Ctilopsis picteti*, though it is exceedingly difficult to make out all the parts seen in a cross-section, especially as this part of the animal seems to have been very strongly contracted in the specimen sectioned. Vagina and penis open into the genital



TEXT-FIG. 5.—T.S. through rectum, anterior hepatic cæcum and hermaphrodite glands. *a.h.c.*, anterior hepatic cæcum. *b.*, cœlom. *c.d.*, common hermaphrodite duct. *d.v.*, duct from seminal vesicle to vagina. *g.*, gut. *m.*, longitudinal muscles of body-wall. *ov.*, ova in diverticula of ventral hermaphrodite gland. *r.*, rectum. *sp.*, spermatozoa and undifferentiated gonadic cells in dorsal hermaphrodite gland. *t.c.*, transverse strands of connective tissue. *v.*, vagina.

atrium a short distance behind the pharynx on the right side. The genital pore lies here a little below the middle line at the level of the œsophagus. No minute papillæ are present on the penis. This is in accordance with the results of other authors, and appears to be a characteristic of *Cephalopyge* as distinct from *Phyllirhoë*, in which the penis is said to be " armed ".

The form of the gonads differs somewhat from previous descriptions. Hanel (1905, p. 458) describes the hermaphrodite glands in *Cephalopyge trematoides* (Chun) as " . . . gelappt oder mit ziemlich grossen zottenformigen Ausstülpungen bedeckt. In diesen werden peripher die Eier, central Spermatozoen gebildet . . . " Five such glands are reported for this species, three lying between the hepatic cæca and two ventrally. André (1906, p. 78) describes three gonads in *Ct. picteti* " . . . formé par les digitations, . . . attachés à un axe ou canal médian ". Dakin and Colefax (1936, p. 459) give a very similar description for their specimens. Baba (1933, p. 158) describes a new species, *Cephalopyge* (*Cephalopyge*) *orientalis* with four gonads " formed of a large testis accompanied by a large number of finger-like ovaries ". Thus the gonads in these three species do not differ to any great extent. Especially is this evident when the different figures are compared. In the present species, however, the hermaphrodite glands are rather irregular, elongated bodies with only a small number of diverticula varying in size according to the degree of development of the ova, which occur mainly in these diverticula (*cf.* Hanel, 1905, p. 458, quoted above). The body of the organ contains developing spermatozoa and small round-cells, either undeveloped gametes or yolk-cells. The gonads thus definitely do not consist of a central axis with numerous lateral finger-like branches.

As mentioned above, the number of hermaphrodite glands is two or three. In no specimen could more than one such gland be definitely traced between the hepatic cæca. In one specimen examined the number of ventral glands appeared to be two, and this interpretation is supported by the terminally forked hermaphrodite duct leading from this organ. The specimen appeared to be young as only a few large eggs were present. In another specimen with more developed eggs in the diverticula it was not possible to distinguish two ventral glands even in the serial sections. It is possible, therefore, that the ventral hermaphrodite gland develops from two centres, and that they grow together, forming a single mass in the adult or ripe animal. In this way it is possible to explain the great variation in the number of gonads recorded in different species, assuming that those with few gonads (two or three) are adult specimens or those carrying ripe eggs and spermatozoa, and that those with many (four or five) are either juvenile specimens or those which have shed the genital products, and in which the gonads have shrunk back to the non-breeding condition. The difficulty of determining the number of glands is also pointed out by Dakin and Colefax (1937, p. 270).

Affinities of *C. arabica* sp. nov.

In the following paragraphs I have kept to the nomenclature used by Thiele (1931, p. 446).

C. arabica agrees with the subgenus *Ctilopsis* as defined by Thiele in having a rudimentary foot, though this is more distinct than that of *Cephalopyge* (*Ctilopsis*) *picteti* (André), ? *Ctilopsis picteti* Dakin and Colefax (1936, p. 456), in which the foot is represented by the pedal gland only, or *Cephalopyge orientalis* Baba. On the other hand, the tapered and rounded tail is far more like that of a typical *Cephalopyge*.

The species differs from *C. trematoides* (Chun) and *C. mediterranea* (Pierantoni) in having a reduced foot. In this it agrees with *C.* (*Ct.*) *picteti* and *C.* (*C.*) *orientalis* Baba. It is sharply distinguished by its elongated rounded tail from *C.* (*Ct.*) *picteti*, in which the tail is short and sharply truncated.

C. arabica agrees most nearly with *C. orientalis* Baba in the absence of a radula, and the presence of a very small foot and long tail, though in this latter species the tail is more abruptly terminated than in the new species. It differs from *C. orientalis* in having only three hermaphrodite glands in the young individual and in the form of the intestine. In

C. orientalis the intestine is a rather broad tube narrowing towards the anus, but in the new species it is an exceedingly narrow tube right from its origin. The tail is more rounded than in *C. orientalis* and has a terminal tuft of setæ not hitherto recorded for any species.

Accordingly I propose to regard it as a new species under the name *Cephalopyge arabica* sp. nov.

Systematic Revision of the Genus *Cephalopyge*.

The family Phyllirhoidæ has been divided into several genera, only one of which, *Phyllirrhoe* Peron et Lesueur, is known from a number of well-defined species. Thiele (1931, p. 446) defines *Phyllirrhoë* as follows : " Körper ziemlich breit, hinten verschmälert, mit vortretender Schnauze und nach vorn gerichteten Rhinophoren ; After an der rechten Seite. " Those species not agreeing with this diagnosis have been given various generic and specific names. The following is a list of these in chronological order :

Phyllirhoë trematoides Chun, 1889	.	*Boopsis mediterranea* } Pierantoni, 1923.
Cephalopyge trematoides Hanel, 1905	.	*Boopsis trematoides* }
Ctilopsis picteti André, 1906	.	*Cephalopyge* (*Cephalopyge*) *orientalis* Baba, 1933.
Ctilopsis trematoides Vessichelli, 1906	.	? *Ctilopsis picteti* Dakin and Colefax, 1936.

The position of some of the various names put forward by authors for *Cephalopyge* species has been briefly summarized by Dakin and Colefax (1937, p. 267), who also give a summary of the species, based on Thiele's classification, admitting four species with the possibility of a fifth to include their Australian specimens. These, however, were later considered to belong to an existing species.

The following discussion is a more detailed review of the nomenclature.

Of the above eight names, *Phyllirhoë trematoides* Chun was shown by Hanel (1905) not to be a *Phyllirhoë*, and was more fully described by that author as the type of a new genus of Phyllirhoid—*Cephalopyge*—under the name *Cephalopyge trematoides* (Chun).

André (1906), unaware of Hanel's work, described specimens from Amboina under the name *Ctilopsis picteti*. This species is distinct from *C. trematoides*, and to it Dakin and Colefax (1936) originally considered their south-east Australian specimens probably belonged, despite certain differences in structure mentioned by these authors. They now (1937) prefer to regard them as a form of *C. orientalis* Baba.

Vessichelli (1906, p. 131) recognized that Chun's species was not a *Phyllirhoë* and placed it in André's genus *Ctilopsis*, apparently unaware of Hanel's erection of the genus *Cephalopyge*. Hence *Ctilopsis trematoides* is a synonym of *Cephalopyge trematoides* (Chun).

Pierantoni (1923, p. 93), overlooking previous work, erected a third genus, *Boopsis*, to receive a specimen described by him under the name *B. mediterranea* from Naples. In considering the imperfectly described *Phyllirhoë trematoides* he remarked that " . . . la specie delle Canarie descritta (assai incompletamente in vero) dal Chun nel 1889 viene compresa nel nuovo genere constituito dalla forma da me rinvenuta ed in anzicchè *Phyllirhoë trematoides* dovrà chiamarsi *Boopsis trematoides* ". Bertolini (1935, p. 68) adhered to this view, following Pierantoni, and likewise having overlooked Hanel's paper. Hence as pointed out by Pruvot (1929, p. 475), " c'est *Boopsis* qui doit tomber, et *Cephalopyge* qui, ayant la priorité, persistera ".

According to Dakin and Colefax (1936, pp. 459–60) the anatomy of ? *Ctilopsis picteti* " strengthens the relationship between the genus *Ctilopsis* and that of *Boopsis* described by Pierantoni . . . ".

Hence on the views of the above authors *Cephalopyge trematoides* (Chun), *Ctilopsis picteti* André and *Boopsis mediterranea* Pierantoni ought to be grouped together in a single genus, in which *Cephalopyge* would have priority. Hence the valid species would be—

Cephalopyge trematoides (Chun),
C. picteti (André),
C. mediterranea (Pierantoni).

When *C. trematoides* is compared with *C. mediterranea* the resemblance is seen to be very great, and Pruvot (1929, p. 475) says: " N'était cette incertitude où nous sommes au sujet de sa radula (Hanel did not examine it closely), je serais de son avis (*i. e.* Pierantoni's view) sur l'identité générique des deux espèces ; et qui plus est, *leur valeur spécifique même me paraîtrait incertaine* " (italics are mine). She adds that the only difference—five gonads instead of two—is much less evident in the figures than in the text. The presence or absence of a radula is important in classifying Nudibranchs, but in no species of *Cephalopyge* is it very highly developed. That shown by Pruvot (1929, p. 468, figs. 3, 4), indeed, appears extremely rudimentary. Hence it is probable that the radula may be more developed in some specimens than in others. Pruvot suggests that once the animal is adult tooth-production may stop and that the radula is degenerate. Thus the radula may even be absent in some adult animals. The question of a radula in *C. trematoides* need not, then, militate against grouping the two species together, and there is reasonable justification for regarding *Boopsis mediterranea* as a synonym of *Cephalopyge trematoides* (Chun). Dakin and Colefax, in their latest paper (1937, p. 267), consider these species as distinct.

The remaining species, *C.* (*C.*) *orientalis* Baba, is quite distinct. To this species, as mentioned above (p. 5), Dakin and Colefax consider their specimens to belong, preferring to regard them as a southern Pacific form of *C. orientalis* Baba from the North Pacific, rather than as a separate species.

Thiele (1931, p. 446) was of the opinion that the species all belonged to one genus, *Cephalopyge*, which he proceeded to divide into two subgenera thus :

(i) *Cephalopyge* s.str., " Fuss deutlich ausgebildet, Schwanz ziemlich lang ". Including *C. trematoides* and *C. mediterranea*.

(ii) *Ctilopsis* André, " Fuss rudimentar, Schwanz kurz und breit, gerade abgestutzt ". Including *C. picteti* only.

This division of the genus was adopted by Baba (1933) in describing *Cephalopyge* (*Cephalopyge*) *orientalis*. Baba gives a list of five characters in which this species " agrees with the genus *Cephalopyge* . . . " (p. 159). The last of these is " (5) in the presence of 3 hepatic sacs, of which *the anterior one is short* " (italics mine). The importance of this last phrase is obvious as describing a character in which it agrees with the subgenus *Ctilopsis*. He excludes it, however, from *Ctilopsis* on the grounds of having an extended tail, a character appertaining to *Cephalopyge* s.str. according to Thiele. On the other hand the foot is rudimentary (" not well-developed "), in which it agrees with *Ctilopsis*.

It is obvious then that this species is intermediate between the two subgenera, and so the division into subgenera breaks down. The present new species, *Cephalopyge arabica*, is likewise intermediate. Dakin and Colefax (1937, p. 268) also consider that the grouping of the species into subgenera is unnecessary.

The following is a more complete diagnosis of the two genera of Phyllirhoidæ, *Phyllirhoë* and *Cephalopyge*.

Family PHYLLIRHOIDÆ.

Genus 1 : *Phyllirhoë*.

Phyllirhoidæ with a distinct proboscis and forwardly directed rhinophores ; hepatic cæca four ; rectum directed backwards ; anus opening on right side near renal pore ; foot absent ; penis armed with papillæ ; accessory genital glands absent.

Genus 2 : *Cephalopyge*.

Phyllirhoidæ with no distinct proboscis and rhinophores laterally directed ; hepatic cæca three, the antero-ventral lost and the antero-dorsal often greatly reduced ; rectum directed forwards ; anus opening in or about the middorsal line immediately behind the head ; foot present, rudimentary or only indicated by the pedal gland ; penis unarmed ; accessory genital glands present.

The four species of *Cephalopyge* can be separated on the basis of the following key.

Genus *Cephalopyge*	Radula present	Anterior hepatic cæcum short ; tail very short, sharply truncated	*Cephalopyge picteti* (André).
		Anterior hepatic cæcum long ; tail long, tapering and truncated	*C. trematoides* (Chun).
	Radula absent	Intestine broad at least at proximal end ; tail long, sharply truncated	*C. orientalis* Baba.
		Intestine a very narrow tube throughout ; tail tapering, rounded posteriorly, with terminal setæ	*C. arabica* sp. nov.

In the above key I have omitted any reference to the hermaphrodite glands for, as stated above (p. 8), I believe the actual number is apparent in the young animals only, being obscured in the adults by the growth of the organs themselves so that only two or at most three are visible. Dakin and Colefax (1937, p. 270) also consider the number of hermaphrodite glands a doubtful character for determining the species.

Genus *Cephalopyge* Hanel.

Cephalopyge picteti (André).

Ctilopsis picteti, André, 1906, p. 72, pl. i.
Ctilopsis picteti, Pierantoni, 1923, p. 93.
Cephalopyge (*Ctilopsis*) *picteti*, Thiele, 1931, p. 446.

RECORDED DISTRIBUTION.—Amboina (André).

DESCRIPTION.—For a description of this species see André, 1906.

REMARKS.—This species was rather incompletely described by André and has not been re-identified since. The species described by Dakin and Colefax (1936) as ? *Ct.*

picteti is nearly related but more probably belongs, as these authors consider, to *C. orientalis* Baba. *C. picteti* André must therefore be regarded as incompletely known.

Cephalopyge trematoides (Chun).

Phyllirhoë trematoides, Chun, 1889, p. 546.
Cephalopyge trematoides, Hanel, 1905, p. 451, pls. xxiii, xxiv.
Ctilopsis trematoides, Vessichelli, 1906, p. 131.
Boopsis trematoides, Pierantoni, 1923, p. 94.
Boopsis mediterranea, Pierantoni, 1923, p. 84, pls. iii, iv.
Boopsis mediterranea, Pruvot, 1929, p. 467, figs. 1–4.
Cephalopyge (*Cephalopyge*) *mediterranea*, Baba, 1933, p. 159.
Boopsis mediterranea, Bertolini, 1935, p. 67, fig. 3.

Recorded Distribution.—Canary Is. (Chun), Mediterranean (Pierantoni, Pruvot, Bertolini).

Description.—See Hanel (1905) and Pierantoni (1923).

Remarks.—Hanel (1905, p. 458) remarks that albumen, shell or other glands are absent. This is probably a mistake due to wrong interpretation of the very complicated genital mass, as other workers on this and other species describe these organs.

Dakin and Colefax (1937 p. 267) regard *C. mediterranea* and *C. trematoides* as separate species, but the differences, as already observed, are scarcely sufficient to warrant the retention of both species. Consequently *C. mediterranea* must be relegated to the position of a synonym of *C. trematoides*.

Cephalopyge orientalis Baba.

Cephalopyge (*Cephalopyge*) *orientalis*, Baba, 1933, p. 157, pl. vii.
? *Ctilopsis picteti*, Dakin and Colefax, 1936, p. 455, pls. iii, iv.

Recorded Distribution.—Shimizu Bay, Japan (Baba); South-east Australia (Dakin and Colefax).

Description.—See Baba, 1933.

Remarks.—Dakin and Colefax (1937), reviewing the position of their specimens, consider that they are nearer to this species than to *C. picteti* (André).

Cephalopyge arabica sp. nov.

Occurrence.—Central and Southern Arabian Sea.

Description.—See p. 1 *et seq.*

Geographical Distribution of the Genus *Cephalopyge*.

The distribution of the four species mentioned above is thus almost world-wide in tropical and subtropical waters. No records are known from the open waters of the Pacific Ocean, but this is doubtless due to our lack of knowledge of much of this region. The very small size of the Phyllirhoidæ is another factor tending to limit our knowledge of the family, as these animals may escape through the meshes of the net, and if caught are readily overlooked in sorting a large mass of zooplankton.

It is worthy of note that those records of *Cephalopyge* spp. for which the time of year is known all lie within the period autumn to winter in both northern and southern hemispheres. These records are tabulated below:

Species.	Author.	Season.	Locality.
C. trematoides	Chun, 1889	. Winter .	Canary Is.
,, ...	Pierantoni, 1923	. ,, .	Naples.
,, ...	Bertolini, 1935	. Nov.–Feb. .	,,
? *C. picteti* (=*C. orientalis* Baba)	Dakin and Colefax, 1936	. Aug.–Sept. .	S.E. Australia.
C. orientalis	Baba, 1933	. Nov .	Japan.
C. arabica	sp. nov.	. Dec., Feb. .	Arabian Sea.

Thus it is probable that the species of this genus become adult, when they would be most likely to be captured owing to increased size, during the autumn, and live throughout the winter. The next generation would then be undergoing its larval development during the following summer when food conditions would be at their best. This is in accordance with Lo Bianco (1888, p. 420), who observed *Phyllirhoë bucephala* laying eggs in March and many with fertile eggs (" uova fecondate ") in March–April. This species also appears at Naples in the autumn and is caught throughout the winter. Schneider (1858, p. 35) also observed recently captured *Ph. bucephala* laying eggs somewhat later, namely in May.

The specimens of *C. arabica* are from localities near the equator where there is no winter as such. They were obtained, however, during the period of the N.E. monsoon, which is the coldest period of the year in the Arabian Sea. They thus agree with the other species in occurring as adults, as far as we know, during the colder part of the year. The specimen from Sta. 131D, taken in February, appears to contain well-developed eggs, so this species also probably breeds at the end of the cold season of the year.

A brief note is perhaps necessary concerning the recent paper by Dakin and Colefax (1936). These workers assert that " the group of the Phyllirhoids to which the genera *Ctilopsis* and *Boopsis* have both been relegated is thus known by *only four specimens* from the world's seas " (italics mine). As they rightly remark, André (1906) had three specimens and Pierantoni (1924) only one; but to these must be added five used by Hanel (1905) in describing *Cephalopyge trematoides,* one described by Pruvot (1929) and " several " known to Baba (1933) and Bertolini (1935). Thus more than a dozen specimens were known previous to the appearance of their paper. To this list must now be added the five specimens from S.E. Australia and the five collected by the " John Murray " Expedition, so that three of the four species recognized above are now each known from a number of specimens. *Cephalopyge trematoides* is particularly well known, having been recorded a number of times from the Gulf of Naples and neighbourhood as well as from the Canary Islands.

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BRITISH MUSEUM (NATURAL HISTORY)

THE
JOHN MURRAY EXPEDITION
1933–34
SCIENTIFIC REPORTS

VOLUME V, No. 2

PTEROPODA

BY

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(Late Scholar of St. Catharine's College, Cambridge)

WITH TWO TEXT-FIGURES

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H.M. STATIONERY OFFICE, LONDON, S.W.1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
1938

Price One Shilling and Sixpence

[*Issued 26th March,* 1938]

DESIGNED AND PRINTED
BY
ADLARD & SON, LTD.
21, HART STREET, W.C.
AT
BARTHOLOMEW PRESS
DORKING

Made and printed in Great Britain

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INTRODUCTION.

THE small collection of Pteropoda contains eighteen species of Thecosomata and two of Gymnosomata, the latter each occurring once only. This is somewhat remarkable, as Meisenheimer (1905, pp. 49 *et seq.*) records the following genera and species of Gymnosomata as having been taken in the area: *Pneumoderma peroni, Pn. mediterraneum, Thliptodon* sp., *Halopsyche gaudichaudi, Notobranchea* sp., and *Clionopsis* sp. The records for these species, however, are not numerous and no examples were taken by the Percy Sladen Expedition, so it is probable that the Gymnosomata are only poorly represented numerically in the Arabian Sea.

The majority of the species included in this report are represented by specimens from only a few localities; nevertheless there are sufficient records to show that many of the species are widely distributed in the Arabian Sea. The presence of Pteropod shells widely distributed on the sea-floor strengthens this belief. Hitherto records of Pteropods in the Arabian Sea have been confined to the Maldive and Chagos Archipelagos, and the course of the "Valdivia" from the Chagos Archipelago to Zanzibar and up the Somali coast to the Gulf of Aden.

Specimens were taken at 16 stations, of which only 4 yielded any number of species, namely, Sta. 131, 12 species; Sta. 61 (night), 12 species; Sta. 96, 8, and Sta. 172, 7 species. It may be remarked that specimens are more abundant from the "high-seas" stations than from the Maldives (only 3 species from 3 stations) and the Red Sea (a species of *Cymbulia* and doubtful remains of a second).

The most widely spread species appear from the records to be *Clio pyramidata* (from 8 localities) and *Cavolinia longirostris* (from 7 localities).

Included in this report are records of a number of specimens of Euthecosomata from the collections of the Indian Museum, for the loan of which I have to thank Dr. Baini Prashad, Director of the Zoological Survey of India.

The classification of the group here adopted is that of Pelseneer (1888), with the modifications of Meisenheimer (1905) and Tesch (1913).

The following is a list of all the species in the collection :

EUTHECOSOMATA.
- LIMACINIDÆ.
  - *Limacina inflata* (d'Orbigny).
  - *L. trochiformis* (d'Orbigny).
- CAVOLINIIDÆ.
  - *Creseis virgula* Rang.
  - *Cr. acicula* Rang.
  - *Hyalocylis striata* (Rang).
  - *Styliola subula* (Quoy & Gaimard).
  - *Clio chaptali* (Souleyet).
  - *C. pyramidata* Linnæus.
  - *C. cuspidata* (Bosc).
  - *Diacria trispinosa* (Lesueur).
  - *D. quadridentata* (Lesueur).
  - *Cavolinia longirostris* (Lesueur).
  - *C. globulosa* (Rang).
  - *C. tridentata* (Forskål).
  - *C. uncinata* (Rang).
  - *C. inflexa* (Lesueur).

PSEUDOTHECOSOMATA.
- CYMBULIIDÆ.
  - *Cymbulia sibogæ* Tesch.
  - *C. ? peroni* de Blainville.

GYMNOSOMATA.
- PNEUMODERMATIDÆ.
  - *Pneumoderma ? pacificum* (Dall).
- CLIONIDÆ.
  - *Clionina longicaudata* (Souleyet).

A. EUTHECOSOMATA.

Family LIMACINIDÆ.

Genus *Limacina* Cuvier.

This genus is represented by two species only and few specimens.

Limacina inflata (d'Orbigny).

Atlanta inflata, d'Orbigny, 1836, p. 174, pl. xv, figs. 16–19.
Spirialis rostralis, Souleyet, 1852, p. 216, pl. xiii, figs. 1–10.
Limacina inflata, Pelseneer, 1888, p. 17.

OCCURRENCE.—Sta. 61 (night), Northern Area of Arabian Sea, surface, 1 specimen.

Limacina trochiformis (d'Orbigny).

Atlanta trochiformis, d'Orbigny, 1836, p. 177, pl. xii, figs. 29–31.
Limacina trochiformis, Pelseneer, 1888, p. 29.

Occurrence.—(i) Sta. 61 (day), Northern Area of Arabian Sea, surface, 2 specimens.

(ii) Sta. 61 (night), Northern Area of Arabian Sea, surface, 2 specimens.

Indian Museum Specimens.—Marine Survey, "Investigator", Sta. 542, off Tavoy I., surface, 1 specimen.

Limacina sp.

Occurrence.—Sta. 136, Maldive Area, surface, 5 specimens.

Remarks.—The shells of these specimens are lost, apparently destroyed by the preservative, thus rendering specific identification uncertain.

Family Cavoliniidæ.

Representatives of six of the seven genera recognized by Meisenheimer are present in the material.

Genus *Creseis* Rang.

The genus is represented by two species.

Creseis virgula Rang.

Creseis virgula, Rang, 1828, p. 316, pl. xvii, fig. 2.
Cleodora virgula, Souleyet, 1852, p. 196, pl. viii, figs. 18–25.
Clio (*Creseis*) *virgula*, Pelseneer, 1888, p. 48.

Occurrence.—(i) Sta. 61 (day), Northern Area of Arabian Sea, surface, 51 specimens.

(ii) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) surface, 35 specimens; (*b*) 1500–0 metres, 1 specimen.

(iii) Sta. 76b, Gulf of Oman: (*a*) 200 metres, 12 specimens; (*b*) 1500 metres, 1 specimen.

(iv) Sta. 96, Central part of Arabian Sea, 400–0 metres, 1 specimen.

Indian Museum Specimens.—(i) S. Point, Port Blair, Andaman I., numerous very small specimens.

(ii) Stewart Sound, N. Andaman I., 2 small specimens.

(iii) Off W. Coast of Strait I., Middle Andaman, 3 small specimens.

(iv) "Investigator" Station off Cape Comorin, 30 fms. (55 metres), 2 specimens.

Creseis acicula Rang.

Creseis acicula, Rang, 1828, p. 318, pl. xvii, fig. 6.
Cleodora acicula, Souleyet, 1852, p. 194, pl. viii, figs. 10–17.
Clio (*Creseis*) *acicula*, Pelseneer, 1888, p. 51.

Occurrence.—(i) Sta. 61 (day), Northern Area of Arabian Sea, surface, 2 specimens.

(ii) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) surface, 40 specimens; (*b*) 1000–0 metres, 2 specimens.

(iii) Sta. 76B, Gulf of Oman, 200 metres, 14 specimens.

(iv) Sta. 95, Central part of Arabian Sea, 984–430 metres, 1 specimen.

(v) Sta. 131D, Southern Area of Arabian Sea, 500–0 metres, 4 specimens.

(vi) Sta. 147, Maldive Area, 27 metres, numerous specimens.

(vii) Sta. 149, Maldive Area, 238 metres, 14 specimens.

Indian Museum Specimens.—(i) W. Coast of Strait I., Middle Andaman, 6 small specimens.

(ii) Stewart Sound, N. Andaman, 11 small specimens.

(iii) "Investigator" Station off Cape Comorin, 30 fms. (55 metres), 18 specimens and empty shells.

(iv) Marine Survey, "Investigator", Sta. 461, Bay of Bengal, 375 fathoms (691 metres), 8 shell-less specimens (day).

(v) Marine Survey, "Investigator", Sta. 542, off Tavoy I., surface, 81 large specimens (night).

Recorded Distribution.—The species has been taken on several occasions by the "Valdivia" and Percy Sladen Expeditions in the Indian Ocean between lat. 3° S. and 10° S.; once at the South end of the Maldive Archipelago (Tesch, 1910, p. 166), and North of Cape Gardafui (Meisenheimer, 1905, p. 16).

Remarks.—Most of the above localities are relatively near to land, but the wide distribution of the new localities indicates that *Cr. acicula* is not confined to inshore or shoal water, but occurs throughout the whole Arabian Sea. Most of the specimens from Sta. 61 (night) are young. The specimens from Stations 147 and 149 were obtained in the grab.

Genus *Hyalocylis* Fol.

Hyalocylis striata (Rang).

Creseis striata, Rang, 1828, p. 315, pl. xv, fig. 7.
Cleodora striata, Souleyet, 1852, p. 191, pl. viii, figs. 1–4.
Clio (Hyalocylix) striata, Pelseneer, 1888, p. 54, pl. ii, fig. 3.

Occurrence.—(i) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) surface, 45 specimens; (*b*) 1000–0 metres, 8 specimens; (*c*) 1500–0 metres, 4 shell-less specimens.

(ii) Sta. 76B, Gulf of Oman, 200 metres, 5 specimens.

(iii) Sta. 96, Central part of Arabian Sea, 645–400 metres, 25 specimens.

(iv) Sta. 131D, Southern Area of Arabian Sea: (*a*) 500–0 metres, 2 specimens; (*b*) 1500–0 metres, 1 shell-less specimen.

(v) Sta. 186, Gulf of Aden, 250–0 metres, 60 specimens.

Indian Museum Specimens.—Marine Survey, "Investigator," Sta. 461, Bay of Bengal, 375 fms. (691 metres), 8 shell-less specimens (day).

Remarks.—The above records for the species indicate a probable distribution over the whole Arabian Sea; there is, however, still a large area between the equator and 10° N. where, except for a single locality off the Maldives, no specimens have been obtained. The specimens from Sta. 61 (night), surface, are all young.

Genus *Styliola* Lesueur.

Styliola subula (Quoy & Gaimard).

Cleodora subula, Quoy & Gaimard, 1827, p. 233, pl. viii *d*, figs. 1–3.
Styliola subula, Gray, 1850, p. 17.
Clio (Styliola) subula, Pelseneer, 1888, p. 57.

Occurrence.—Sta. 61 (night), Northern Area of Arabian Sea, 1500–0 metres, 1 specimen.

Recorded Distribution.—In the Indian Ocean the species is most abundant between 25° S. and 34° S., except round the Cape of Good Hope, where it extends considerably farther southwards. Only six localities have been noted—two on the East African Coast, one off Mauritius, one on the Saya de Malha Bank (Tesch, 1910), and two in the Eastern part of the Indian Ocean.

Remarks.—The scarcity of the species in the northern part of the Indian Ocean and the Arabian Sea is in accordance with Meisenheimer's statements (1905, p. 19) regarding its distribution. The distribution of the species on the East African Coast can possibly be attributed to the presence there of cooler Antarctic water flowing up the African coast.

Genus *Clio* (s. str.) Linnæus.

This genus is represented by three species.

Clio chaptali (Souleyet).

Cleodora chaptali, Souleyet, 1852, p. 183, pl. vii, figs. 1–5.
Clio chaptali, Pelseneer, 1888, p. 61, pl. ii, fig. 7.

Occurrence.—(i) Sta. 131d, Southern Area of Arabian Sea, 500–0 metres, 1 specimen.

(ii) Sta. 172, Central part of Arabian Sea, 2091 metres, 1 specimen.

Recorded Distribution.—This species is only known from three previous localities : West of the Cape of Good Hope (Souleyet, 1852), off the East coast of Australia (Pelseneer, 1888), and from between the Canary Islands and Cape Blanco (Meisenheimer, 1905).

Remarks.—The species appears to be widely distributed in tropical and subtropical waters, but nowhere seems to occur in large numbers.

Clio pyramidata Linnæus.

Clio pyramidata, Linnæus, 1767, p. 1094.
Cleodora lanceolata, Souleyet, 1852, p. 179, pl. vi, figs. 17–25.
Clio (Clio) pyramidata, Pelseneer, 1888, p. 63.

Occurrence.—(i) Sta. 61 (day), Northern Area of Arabian Sea, 500–0 metres, 2 specimens.

(ii) Sta. 61 (night), Northern Area of Arabian Sea : (*a*) surface, 7 shell-less specimens ; (*b*) 1000–0 metres, 6 specimens ; (*c*) 1500–0 metres, 6 shell-less specimens.

(iii) Sta. 95, Central part of Arabian Sea, 984–430 metres, 14 shell-less specimens.

(iv) Sta. 96, Central part of Arabian Sea, 645–400 metres, 1 specimen.

(v) Sta. 98, Central part of Arabian Sea, 2800–0 metres, 1 specimen.

(vi) Sta. 131D, Southern Area of Arabian Sea, 500–0 metres, 2 specimens.

(vii) Sta. 172, Central part of Arabian Sea, 850–0 metres, 2 specimens.

(viii) Sta. 186, Gulf of Aden, 250–0 metres, 1 specimen.

REMARKS.—*Clio pyramidata* is one of the commonest Pteropods in the Arabian Sea; it is a conspicuous constituent of the Pteropod ooze to be found at the Southern end of the Red Sea and in the Gulf of Aden.

Clio cuspidata (Bosc).

Hyalæa cuspidata, Bosc, 1802, p. 241, pl. ix, figs. 5–7.
Cleodora cuspidata, Souleyet, 1852, p. 176, pl. vi, figs. 11–16.
Clio (*Clio*) *cuspidata*, Pelseneer, 1888, p. 66.

OCCURRENCE.—(i) Sta. 96, Central part of Arabian Sea, 645–400 metres, 3 specimens.

(ii) Sta. 131D, Southern Area of Arabian Sea, 2500–0 metres, 1 shell-less specimen.

(iii) Sta. 172, Central part of Arabian Sea; (*a*) 400–0 metres, 1 specimen; (*b*) 850–0 metres, 2 specimens; (*c*) 2091 metres, 1 specimen.

Genus *Diacria* Gray.

Diacria trispinosa (Lesueur).

Hyalæa trispinosa, Lesueur, 1821, p. 82.
Diacria trispinosa, Gray, 1850, p. 10.
Hyalæa trispinosa, Boas, 1886, p. 94, pl. i, fig. 3, pl. ii, fig. 14.

OCCURRENCE.—Sta. 131D, Southern Area of Arabian Sea, 500–0 metres, 1 specimen.

RECORDED DISTRIBUTION.—Almost all previous records for the species in the Indian Ocean are south of the equator; there is a single record from the Bay of Bengal. It appears to be abundant south-east of the Cape of Good Hope, but less so further east in the Indian Ocean and decreases in numbers rapidly northwards. The most northerly localities so far recorded are north of the Chagos Archipelago and in the Amirante Group (Tesch, 1910, p. 167) and the "Valdivia" stations 226 and 257, west of Chagos and off the East African Coast respectively (Meisenheimer, 1905, p. 28).

REMARKS.—The species appears to be most abundant in the South-west Indian Ocean and very rare north of the equator, in the Arabian Sea. Deposit shells, but no living animals, have been found in the Gulf of Aden, but not elsewhere in the northern Arabian Sea.

Diacria quadridentata (Lesueur).

Hyalæa quadridentata, Lesueur, 1821, p. 81.
Hyalæa quadridentata, Boas, 1886, p. 99, pl. i, fig. 4, pl. ii, fig. 15.
Cleodora pygmæa, Boas, 1886, p. 84, pl. iv, figs. 50, 57, 57 *bis*, pl. v, fig. 90.
Diacria quadridentata, Meisenheimer, 1905, p. 29.

OCCURRENCE.—(i) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) Surface, 2 specimens; (*b*) 1000–0 metres, 6 specimens; (*c*) 1500–0 metres, 1 specimen.

(ii) Sta. 96, Central part of Arabian Sea: (*a*) 10 metres, 22 specimens; (*b*) 645–400 metres, 1 specimen.

(iii) Sta. 131D, Southern Area of Arabian Sea, 500–0 metres, 1 specimen.

(iv) Sta. 172, Central part of Arabian Sea, 800–0 metres, 1 specimen.

Remarks.—One specimen from Sta. 61, 1000–0 metres, and all those from Sta. 96, 10 metres, are of the young form "*Cleodora pygmæa*" Boas.

Genus *Cavolinia* Abildgaard.

This genus is represented by five of the six known species.

Cavolinia longirostris (Lesueur).

Hyalæa longirostris, Lesueur, 1821, p. 81.
Hyalæa lævigata, d'Orbigny, 1836, p. 110, pl. vii, figs. 15–19.
Hyalæa longirostris, Boas, 1886, p. 102, pl. i, fig. 5, pl. ii, fig. 16.
Cavolinia longirostris, Pelseneer, 1888, p. 79.

Occurrence.—(i) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) Surface, 11 specimens; (*b*) 1500–0 metres, 1 specimen.

(ii) Sta. 76a, Gulf of Oman, surface, 1 specimen.

(iii) Sta. 76b. Gulf of Oman: (*a*) 200 metres, 10 specimens; (*b*) 2500 metres, 3 specimens.

(iv) Sta. 94, Central part of Arabian Sea, 1045–984 metres, 1 specimen.

(v) Sta. 95, Central part of Arabian Sea, 984–430 metres, 16 specimens.

(vi) Sta. 96, Central part of Arabian Sea: (*a*) 10 metres, 9 specimens; (*b*) 645–400 metres, 13 specimens.

(vii) Sta. 131d, Southern Area of Arabian Sea, 500–0 metres, 16 specimens.

(viii) Sta. 172, Central part of Arabian Sea: (*a*) 200–0 metres, 23 specimens; (*b*) 400–0 metres, 28 specimens; (*c*) 850–0 metres, 59 specimens; (*d*) 2091–0 metres, 245 specimens.

(ix) Sta. 186, Gulf of Aden, 2500–0 metres, 1 specimen.

Indian Museum Specimens.—(i) Marine Survey, "Investigator", Sta. 542, off Tavoy I., surface, 119 specimens.

(ii) Marine Survey, Sta. 556, off Tavoy I., surface, 7 specimens.

(iii) "Investigator", North Point Andaman I., surface, 9 specimens.

(iv) "Investigator", off Moscos I., 29 small specimens.

Remarks.—Two specimens from Sta. 96, 10 metres, and one from Sta. 131d, are of the young form "*Hyalæa lævigata*" d'Orbigny.

Cavolinia globulosa Rang.

Cavolinia globulosa, Rang, 1850, p. 8.
Hyalæa globulosa, Boas, 1886, p. 107, pl. i, fig. 7, pl. ii, fig. 18.
Cavolinia globulosa, Pelseneer, 1888, p. 81.

Occurrence.—(i) Sta. 96, Central part of Arabian Sea, 645–400 metres, 6 specimens.

(ii) Sta. 131d, Southern Area of Arabian Sea, 2500–0 metres, 2 specimens.

(iii) Sta. 172, Central part of Arabian Sea: (*a*) 200–0 metres, 2 specimens; (*b*) 400–0 metres, 2 specimens.

Indian Museum Specimens.—(i) Marine Survey, "Investigator", Sta. 461, Bay of Bengal, 375 fms. (691 metres), 1 specimen.

(ii) Mita, Tavoy, Burma, 4 specimens.

Remarks.—The species is common in the Bay of Bengal and eastern part of the Indian Ocean, and probably occurs almost as frequently in at least the central and southern parts of the Arabian Sea. At present it is unknown from the northern part and the Gulf of Oman.

Cavolinia tridentata (Forskal).

Anomia tridentata, Forskål, 1773, p. 124.
Hyalœa complanata, Gegenbaur, 1855, p. 40.
Hyalœa tridentata, Boas, 1886, p. 115, pl. i, figs. 8, 9, pl. ii, fig. 19, pl. iv, fig. 66, pl. vi, fig. 100.
Cavolinia tridentata, Pelseneer, 1888, p. 83.

Occurrence.—(i) Sta. 131d, Southern Area of Arabian Sea, 500–0 metres, 1 specimen.

Remarks.—The species seems to be more abundant in the southern and eastern portions of the Indian Ocean. North of the equator the species is practically unknown except for occasional remains in the bottom deposits. These remains are more common on the African coast. Meisenheimer says of *C. tridentata* : " . . . häufig ist sie (dann weiter) im ganzen indischen Ocean, wo ihre Sudgrenze . . . auf 40° S. Br. liegt . . . " His chart, however (Karte vi), of the distribution of the species scarcely bears out this statement, for he gives 25 localities south of Lat. 25° S. and only 5 north of this line. The failure of the expedition to capture *C. tridentata* north of the equator would seem to indicate that the Arabian Sea lies rather outside the zone of distribution of this species and that it occurs only sparsely here, though if the dead shells may be taken as a guide, it is more abundant on the western side of the sea.

The species has never been taken alive in the northern and central parts of the Arabian Sea, though occasional deposit shells are found in the Gulf of Aden. From its scarcity, where known, in the area it is not unlikely that it may be absent from the northern part of the Arabian Sea and the Gulf of Oman.

The single specimen obtained belongs to the young form " *Hyalœa complanata* " Gegenbaur (1855, p. 40).

Cavolinia uncinata (Rang).

Hyalœa uncinata, Rang, 1836, p. 93, pl. v, figs. 11–15.
Hyalœa uncinata, Boas, 1886, p. 119, pl. i, fig. 10, pl. ii, fig. 20.
Cavolinia uncinata, Gray, 1850, p. 7.

Occurrence.—(i) Sta. 95, Central part of Arabian Sea, 984–430 metres, 1 specimen.

(ii) Sta. 96, Central part of Arabian Sea : (*a*) 10 metres, 2 specimens ; (*b*) 645–400 metres, 7 specimens.

Indian Museum Specimens.—(i) " Investigator ", Northern part of Andaman Sea, surface, 16 specimens.

(ii) Marine Survey, " Investigator ", Sta. 274, Laccadive Sea, 1170–1150 fms. (2160–2123 metres), 1 specimen.

Cavolinia inflexa (Lesueur).

Hyalœa inflexa, Lesueur, 1813, p. 285, pl. v, fig. 3.
Hyalœa inflexa, Boas, 1886, p. 123, pl. i, fig. 11, pl. ii, fig. 21, pl. vi, figs. 98 *a–l*.
Cavolinia inflexa, Pelseneer, 1888, p. 85.

Occurrence.—Sta. 96, Central part of Arabian Sea, 10 metres, 1 specimen.

Recorded Distribution.—Except for a single record in the Bay of Bengal all previous records for the species in the Indian Ocean are from south of the equator.

Remarks.—This single specimen has the shell completely decalcified by the preservative, but is quite intact and distinctly of the typical form of *C. inflexa*.

B. PSEUDOTHECOSOMATA.

Family Cymbuliidæ.

Genus *Cymbulia*.

The genus is represented by one species and fragments of what may be a second species.

Cymbulia sibogæ Tesch.

Cymbulia sibogæ, Tesch, 1904, p. 54, pl. iii, figs. 88–90.

Occurrence.—(i) Sta. 7, Red Sea, 260 metres, 237 specimens, 2633 empty shells.

(ii) Sta. 131D, Southern Area of Arabian Sea, 2500–0 metres, 2 specimens.

Recorded Distribution.—Specimens are known from the East Indies (Tesch, 1904, p. 54), Gulf of Guinea, North of Cocos I., South of Ceylon, Chagos Archipelago, Seychelles, South-east of Cape Gardafui (Meisenheimer, 1905, p. 38).

Young specimens, probably of this species but without the deutoconch, are recorded from the following additional areas : Amirante Group, Gulf of Aden (Meisenheimer, 1905, p. 38), Mauritius, Providence and Farquhar Atolls (Tesch, 1910, p. 168).

Remarks.—The collection from Sta. 7 consists almost entirely of shells ; there are only 237 animals, all separated from the shell. Only 85 of these animals have the " tail " well developed on the ventral fin, the others being tailless. All the shells appear to be those of young animals varying in size from 11·0 mm. to 22·0 mm. The largest specimens are thus slightly smaller than the largest collected by the " Siboga ". Meisenheimer (*loc. cit.*), however, records very much larger specimens averaging 30·0 mm. in length, some being 39·0 mm. long—more than half as long again as the type-specimens, the largest of which only measured 24·0 mm. in length.

The specimens from Sta. 131 are 2 shells and 2 shell-less animals, but as they are the only animals of this type from this station it is highly probable that shells and animals belong to one another.

All the tests differ from the type in having a much more acute dorsal end and the rows of spines on the aboral surface somewhat sinuous. In the type these latter are said to be straight. The specimens, however, are not referable to either the large or small types of *C. peroni* de Blainville on account of the acute dorsal end, the small equal spines and the rows of spines running to the ventral point being sinuous and not simply curved.

Cymbulia sp.

Occurrence.—(i) Sta. 18, Gulf of Aden, 900–0 metres, 2 specimens.

(ii) Sta. 61 (night), Northern Area of Arabian Sea: (*a*) 1000–0 metres, 2 small specimens; (*b*) 1500–0 metres, 1 small specimen.

(iii) Sta. 131D, Southern Area of Arabian Sea: (*a*) 500–0 metres, 5 specimens; (*b*) 1500–0 metres, 12 specimens.

(iv) Sta. 170, Central part of Arabian Sea, 3676 metres, 1 large damaged specimen.

(v) Sta. 172, Central part of Arabian Sea, 200–0 metres, 7 specimens.

Remarks.—These specimens all resemble *C. sibogæ*, but as all have lost the deutoconch it is impossible to identify them with certainty.

If these shell-less specimens are included it would seem that the species is common in the southern half of the Arabian Sea and at least present in the northern half of the area. Moreover it penetrates into the Red Sea, as is evident from the large haul of specimens at Sta. 7, though probably it does not extend very far northwards in this area.

Cymbulia ? peroni de Blainville.

Cymbulia peroni, de Blainville, 1818, p. 333, pl. lix, fig. *a*.

Occurrence.—Sta. 7, Red Sea, 260 metres, fragments.

Remarks.—These fragments appear to belong to a number of specimens of some large species of *Cymbulia*. Some of them are covered with small denticles similar to those which form a large patch on the aboral surface of *C. peroni*, but it is not possible to be sure that they belong to this species.

c. GYMNOSOMATA.

The Gymnosomata are represented by two genera belonging to different families.

Family Pneumodermatidæ.

Genus *Pneumoderma* Cuvier.

This genus is represented by two specimens belonging to one species.

Pneumoderma ? pacificum (Dall).

Pneumodermon pacificum, Dall, 1871, p. 139.
Pneumonoderma pacificum, Pelseneer, 1887, p. 30, pl. ii, figs. 4, 5.
Pneumoderma pacificum, Meisenheimer, 1905, p. 50.

Occurrence.—Sta. 61 (night), Northern Area of Arabian Sea, surface, 2 specimens.

Recorded Distribution.—This species was first recorded by Dall from the West coast of North A erica, since when it has been taken several times in the North Pacific between latitudes 30° N. and 40° N.. and as far north as 58° N. (Alaska) on the eastern side of the Pacific. It has not previously been obtained outside the Pacific.

Remarks.—The specimens are only indifferently preserved and are considerably contracted, but they appear to conform most nearly to the descriptions of this species.

Family Clionidæ.

The various species of gymnosomatous Pteropoda referable to the family Clionidæ have had a somewhat chequered history. The early history of the family is summarized by Pelseneer (1887), who adopted the name *Clione* Pallas for those Gymnosomata hitherto described under the name *Clio*, which name he transferred on grounds of priority to a series of thecosomatous species. Pelseneer reduced the number of reasonably well-defined species, identifiable from the literature, to three, namely *Clione limacina*, *Cl. longicaudata* and *Cl. flavescens*. He rejected the suggestion put forward by Macdonald (1864, p. 187) that the species should be generically separated on the number of pairs of buccal cones into those with three and those with two pairs.

By 1923 three new genera, *Paraclione* (Tesch, 1904), *Pædoclione* (Danforth, 1908) and *Cephalobrachia* (Bonnevie, 1914), had been added to the Clionidæ and the number of accepted species of *Clione* had increased to seven, namely :

Clione limacina	Pelseneer, 1887.	*Cl. gracilis* Massy, 1907.
Cl. longicaudata		*Cl. antarctica* E. A. Smith, 1902.
Cl. flavescens		*Cl. kincaidi* Agersborg, 1923.
Cl. punctata Tesch, 1904.		

Pruvot-Fol (1924) investigated in detail the anatomy of the head-region in *Cl. longicaudata*, and found constant differences between this species and *Cl. limacina* in the structure of the radula, buccal cones, hook-sacs and penis. On the basis of these facts she subdivided *Clione* into two genera, *Clione* s. str. including *C. limacina* (Phipps) and other species with six buccal cones, and *Clionina* for *Cl. longicaudata* and possibly *Cl. flavescens* which have four buccal cones.

The single specimen in the collection belongs to the genus *Clionina*.

Genus *Clionina* Pruvot-Fol.

Clionina longicaudata (Souleyet).

Spongiobranchia elongata, d'Orbigny, 1840, p. 132, pl. ix, figs. 8, 9.
Clione caudata, Gray, 1850, p. 37.
Clio longicaudatus, Souleyet, 1852, p. 286, pl. xiv, figs. 17–21.
Clionina longicaudata, Pruvot-Fol, 1924, p. 364, pl. xv, figs. 15–17, text-figs. 14–17.

Occurrence.—Sta. 61 (night), Northern Area of Arabian Sea, surface, 1 specimen.

Recorded Distribution.—This species has been frequently recorded from the Atlantic by the "Challenger", "Valdivia" and the Plankton-expedition within a belt extending from 4° N. to 36° N. and extending to nearly 40° N. in the Gulf Stream. It has been recorded several times from the Eastern Mediterranean (Kwietniewski, 1902 ; Lo Bianco, 1903 ; Pruvot-Fol, 1924). It has not previously been taken in the Indian Ocean.

THE VERTICAL DISTRIBUTION OF THE PTEROPODA.

Oberwimmer (1898, p. 573), working on material from the Mediterranean and considering all the species of Pteropoda and Heteropoda together, found that the maximum number of individuals was obtained at the surface between 18.45 and 20.45 hrs., and that from then on less were caught—apparently as a result of the downward migration of the animals. A second, though smaller, surface maximum occurred between 3.45 and 5.30 hrs., *i. e.* at dawn. By day few or no specimens were caught at the surface. Thus the double diurnal rhythm is more or less universal within these two groups of animals, though it is highly probable that different species vary in their time of actual maximum surface concentration according to their sensitivity to light

In the following paragraphs only those species are mentioned for which there are several records in the present collection and of which a fair number of specimens are available.

In dividing the present records into " night " and " day " stations for constructing the distribution diagrams, the hours from 6.00 to 18.00 have been regarded as day, this period corresponding approximately to the duration of daylight in the Arabian Sea. The diagrams give only an approximate illustration of the range of distribution, owing to the small number of specimens captured at almost all depths save that at which the maximum concentration occurs. Hence the lower parts of the figures are for the most part doubtful, *e. g.* Text-fig. 1, C and F, where only a few specimens were obtained from the greater depths.

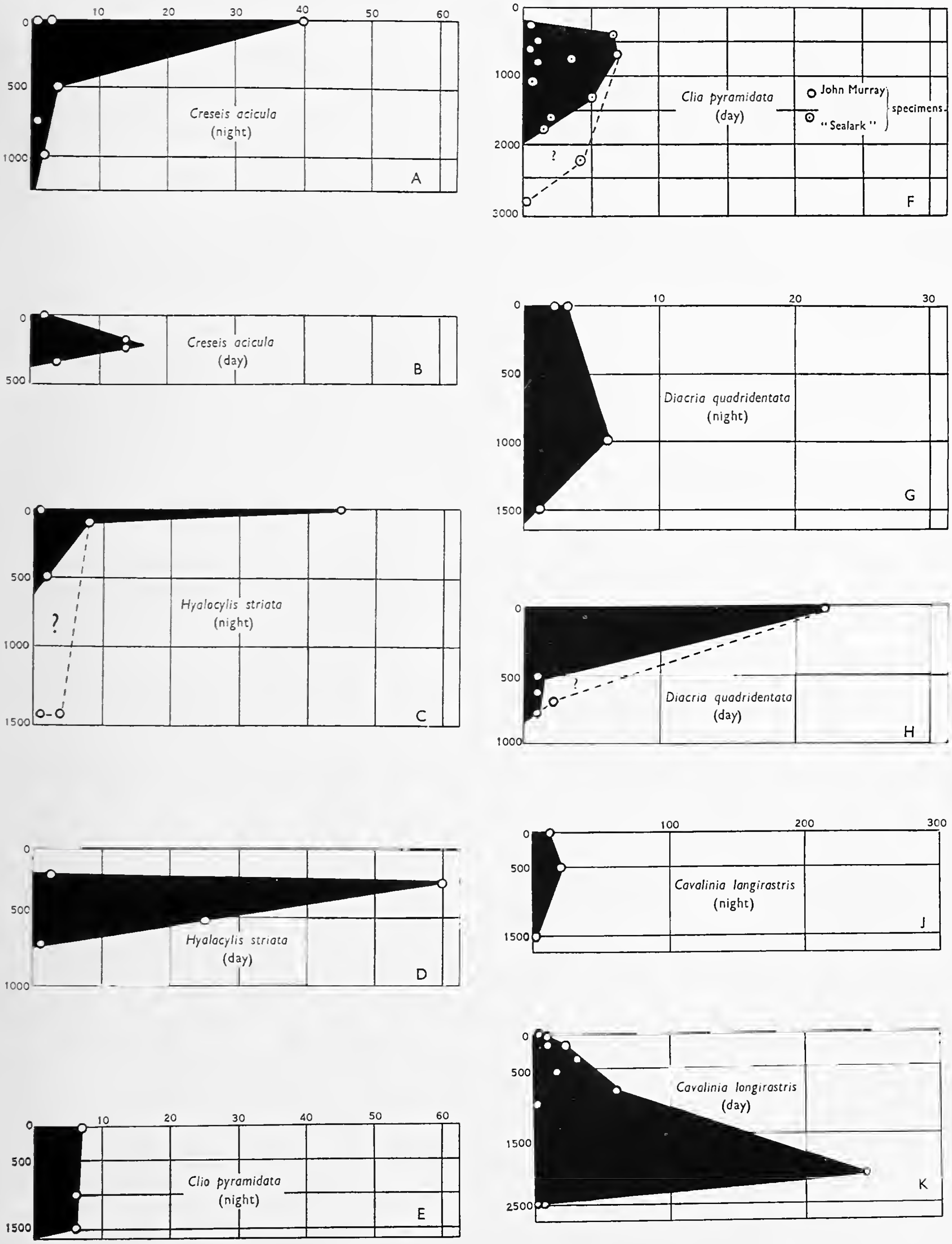
Creseis virgula.

Fryer (1869, p. 269) has stated that *Cr. virgula* occurs at the surface throughout the 24 hours. The present records, though not extending over a whole day, indicate a surface maximum in the afternoon (*c.* 13.00–14.00 hrs.). The record from Sta. 61 (night), 1.30 hrs., shows a high concentration of the species at the surface, apparently indicating a second surface maximum concentration in the early hours, and thus a double diurnal migration towards the surface. If this is so it would appear that the vertical migration of *Cr. virgula* is not controlled by light-intensity, but by some other stimulus such as the need for food or the physical conditions in the water. It is unfortunate that there is only one record, and that of a single specimen, for the period 2.00–12.00 hrs., as such a record would probably establish whether the species remains at the surface or descends, to rise again in the afternoon.

The species evidently inhabits the upper 200 metres, but the records are insufficient to indicate how much deeper it may go.

Creseis acicula (Text-fig. 1 A, B).

Creseis acicula seems to appear at the surface in numbers at night only. The present records indicate only a comparatively short vertical range of about 500 metres, with a daylight concentration at about 250 metres. Fryer (1869, p. 269) lists this species also as occurring at the surface throughout the 24 hours. Only a few, however, appear to remain in the upper strata during the period of intense illumination. It is interesting to note that at the shallow-water stations 147 and 149 in Horsburgh Atoll this species was



TEXT-FIG. 1.—Vertical distribution by day and night of the more abundant species: A, B, *Creseis acicula*; C, D, *Hyalocylis striata*; E, F, *Clio pyramidata*; G, H, *Diacria quadridentata*; J, K, *Cavolinia longirostris*.

abundant, and had evidently migrated right to the bottom in considerable numbers and thus was brought up by the grab. Sewell (1935, p. 526) has recorded the great abundance of *Clio* sp. (probably this species or *Cr. virgula*) in the shallow water of an atoll. He says: "On one occasion over a litre and a half of a species of Pteropod, *Clio* sp., were taken in a surface townet . . . that was left awash at the surface for a period of twelve hours." *Cr. acicula*, like *Cr. virgula*, must be able to withstand a comparatively high light-intensity as it occurs in very shallow water, *e. g.* 28 metres at Sta. 147, where even at the bottom the illumination must still be strong.

Hyalocylis striata (Text-fig. 1 c, d).

This species appears to frequent a depth between 200 and 500 metres by day, but quite obviously rises to the surface at night (Text-fig. 1 c). It is possible that the specimens obtained from 1500 metres were caught during the hauling of the net and so belong to a much higher level, as it is not likely that the animals would both ascend and descend from the day position under the same set of conditions. This species also is listed by Fryer (1869, p. 269) as occurring at the surface by day and night, again probably due to its capability of withstanding a fairly high light-intensity, and so descending later and to a less depth than other and more sensitive species.

Clio pyramidata (Text-fig. 1 e, f).

The daylight distribution of this species appears to lie below 250 metres, with a maximum concentration somewhere between 430 and 984 metres. The "Sealark" Expedition obtained a maximum concentration of this species at about 369 metres, so 400–500 metres is probably near the level occupied by *Clio pyramidata* by day. Ignoring the single specimen from 2800–0 metres, probably caught as the net was hauled, the indicated lower limit for the present collection is about 900 metres. The "Sealark" obtained specimens from considerably greater depths, indicating a possible range to about 2000 metres or more, though this is unlikely. Lo Bianco also (1903, pp. 142 *et seq.*) obtained specimens from the Mediterranean at a depth of 1900 metres with both closed and open nets, and also from 2600 metres with an open net. The latter specimens were young, and may have been caught by the net on its way to the surface. Young individuals are not confined to very deep water, as the same author records them from 900, 1100 and 1200 metres. Hence the species probably has a vertical range of about 2000 metres.

The night distribution is clearly shown by the records from Sta. 61 (Text-fig. 1 e). Almost equal numbers were collected from 0, 1000 and 1500 metres, indicating that all the individuals do not rise to the surface, but that there is a general upward movement of the animals, filling up the surface layers. Owing to the great distance to the surface the stimulus drawing them upwards is probably removed before the bulk of the animals reach the surface, and they then become evenly distributed in the upper 1500 metres. Thus only those lying nearest the surface by day will reach it at night. Russell (1925, p. 791; 1926, p. 432) has shown that this is probably so for *Calanus finmarchicus* and the medusa *Cosmetira pilosella*. This distribution is what might be expected from a consideration of the daytime distribution of *Clio pyramidata*, as it is scarcely conceivable that these animals could migrate through 2000 metres or more each night.

This species also has occasionally been recorded at the surface during daylight. The large vertical range with its attendant change of temperature is in full agreement with Bonnevie's view (1914, p. 51) that this is an eurythermal species.

Clio cuspidata.

The few available records point to a daytime range from about 400–900 metres with a maximum concentration at about 500 metres. No specimens were obtained in the night plankton hauls.

Diacria quadridentata (Text-fig. 1 G, H).

Fryer (1869, p. 269) records this species from the surface during daylight. This is to some extent confirmed by the present records. The night hauls indicate a possible concentration at 1000 metres, but 8 hours later a distinct maximum is found at 10 metres, *i. e.* at the surface. Unfortunately there are no records for the rest of the day. The "Sealark" Expedition, however, found specimens at 738 metres at noon (Tesch, 1910, pp. 167, 171), so there is a possibility that *D. quadridentata* descends again during the period of highest illumination, in which case it probably reappears at the surface at twilight, thus having a double diurnal migration like *Cr. virgula*. *D. quadridentata* would seem to prefer the less intensive illumination to be found at dawn and twilight. Owing to this crepuscular habit the diagrams (Text-fig. 1 G, H) tend to give a slightly distorted impression, as no distinction is made between full daylight and the weak light of dawn and evening. The surface daylight distribution (Text-fig. 1 H) is not a permanent daytime position, but only occurs in the early hours (the actual maximum charted occurred at 9.10 hrs.) and perhaps again in the evening.

Cavolinia longirostris (Text-fig. 1 J, K).

There appears to be a considerable concentration of this species at about 2000 metres by day (Text-fig. 1 K). At night, apparently, the animals may be distributed more or less evenly throughout the top 800 metres (Text-fig. 1 J), perhaps rather more densely at 500 metres, below which level they become less frequent. A considerable number seem to occur at this depth throughout the 24 hours. It is not possible from the present results to determine when the greatest frequency at the surface occurs. There is, however, a large concentration of animals at 2000 metres in the afternoon which indicates that they are heliophobic and hence probably only rise to the surface at night. Bonnevie (1914, p. 51) classes this species as a surface-living, stenothermal form, as the "Michael Sars" only obtained it in the Atlantic from above 250 metres and mainly at the surface. The present records clearly indicate that *C. longirostris* is a distinctly eurythermal species. At Sta. 172 it was taken in water of temperature ranging from about 15° to 3·5° C.

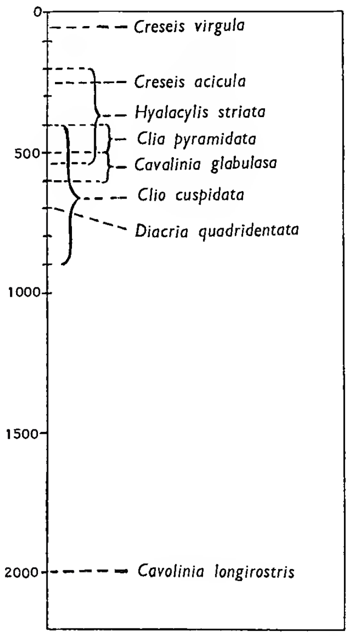
Cavolinia globulosa.

The present records indicate a daytime distribution at about 500–600 metres for this species. The "Sealark" records (Tesch, 1910, pp. 169–171) indicate a much lower level, namely, at about 1400 metres. As, however, only a few specimens were obtained by either expedition, it is difficult to determine at what level the animals lie during the day.

The most specimens (10) were obtained from 1400 metres (Tesch, 1910, p. 171). There is only a single record for a night haul, and so it is impossible to determine at what time the species is at the surface.

GENERAL REMARKS ON VERTICAL DISTRIBUTION.

The different depths at which the various species of Pteropods occur during the day and the different times at which they appear at the surface—at night, dawn, early morning, etc.—indicate that the different species probably prefer different light-intensities. Presumably this preference determines their distribution in depth. Text-fig. 2 shows



Text-fig 2.—Vertical distribution of various species by day.

the depths at which the species discussed above occur by day. Oberwimmer (1898, p. 573), as mentioned above, obtained an average time of appearance at the surface which showed that the majority were crepuscular animals appearing at the surface at dawn and in the evening. Still earlier, Fryer (1869, p. 269) classified the Pteropoda to be met with in the South Atlantic and Indian Ocean as night, day or crepuscular animals. He concluded that many species were present at the surface at all times. This was probably due to the longer period spent at the surface by some species compared with others. Meisenheimer (1905, p. 98) came to the conclusion that the Eu- and Pseudothecosomata must be regarded as coming to the surface at night (" Nachttiere ") and the Gymnosomata by day (" Tagtiere ").

The problem does not, however, admit of such a simple settlement. It seems fairly clear that some species prefer a higher or lower light intensity than others and hence appear at the surface at different times. Moreover they will descend to a greater or less depth depending on whether the day is brilliant or dull, and also on whether the water is clear, thus admitting of greater light penetration, or is cloudy. It is more than probable that the suggestion put forward by Michael (1911, pp. 133, 144) for *Sagitta bipunctata*—that the animal lives at an optimum light intensity—is applicable to the movements of the Pteropoda. At sundown this species follows this optimum surface-wards, but after dark the stimulus to ascend is removed and the animals sink back probably to the water layers offering the best combination of other factors, such as temperature and perhaps salinity. With the coming of dawn the animals rise to meet the optimum and follow it downwards. Hence the second appearance at the surface and the double diurnal rhythm as indicated for *Cr. virgula* and *D. quadridentata* and perhaps other species. Those species preferring a very low light intensity will rise very near to the surface at night, whereas those liking a high intensity will lose the stimulus earlier and so begin to sink back earlier in the night. At dawn the reverse process will occur, those liking a low intensity preceding the others at the surface. As the intensity increases during the morning the last to leave the surface will be forms such as *Cr. virgula* and *Cr. acicula*, which prefer a fairly high light intensity and consequently never sink to a very great depth. For instance, the present materials indicate that *Cr. acicula* has a maximum daylight concentration at only about 250 metres, whereas other species sink to 1000 or even 2000 metres (*Cavolinia longirostris*). Michael (1911, p. 145) has pointed out that " . . . *a few almost always remain in deeper water during twilight, and on the surface during intense light and darkness* ". This statement is made for the species of *Sagitta*, but apparently it applies equally to some of the Pteropoda, such as *Creseis* spp., and this would account for the statements of some observers that these forms are surface-living during daylight.

It is of interest to note that those species that were found in any numbers at Sta. 76 in 200 metres, namely *Creseis virgula*, *Cr. acicula*, *Hyalocylis striata* and *Cavolinia longirostris*, were also found to be common at the surface at Sta. 61 either by day or night or both (*Cr. virgula*). Apparently the conditions here are equally suitable for all four species, though *C. longirostris* is also found at considerable depths, whereas the other species are usually to be found in the upper 500 metres. One other species, *Clio pyramidata*, was fairly common at Sta. 61 at the surface, but also occurred here in about the same numbers at 1000 and 1500 metres, and so was not confined to the particular water mass inhabited by the preceding four species. This species did not occur at Sta. 76. These four species were not found in as large numbers at other depths at these stations though elsewhere they occurred at much greater depths, *e.g. C. longirostris* was very common at 2000 metres at Sta. 172 in water of Polar origin. Hence the particular conditions at these two stations are apparently not essential for this latter species, though they may offer the optimum conditions in these localities. The following data for these two positions are of interest :

Station.	Time.	Depth (m.).	Temperature (° C.).	Salinity.	Number of specimens.
76	15.30	200	17·48	36·24	14
61 (night)	1.26	0	27·83	36·27	40

It is thus seen that the animals were here living at different depths (the depth being probably dependent upon the time of day) and under very different conditions of temperature. The animals at Sta. 76 have doubtless descended because of the high light intensity of the afternoon, whereas at Sta. 61 in the dark they are at the surface. Apparently the stimulus of light is stronger than that of temperature, as otherwise the animals would hardly move through water with such a large range of temperature.

It is interesting to see that these two bodies of water have very nearly the same salinity. This suggests that the particular depth assumed by day by these four species may be to some extent linked with the salinity, the particular depth taken up being that in which the light intensity is not too great and the salinity is somewhere about 36·25, regardless of the temperature of the water. Unfortunately the records from other stations do not support this suggestion. At Sta. 172, to take one example, specimens were found at varying depths to 2091 metres, and the salinity varied considerably from 35·50 at 200 metres to 34·88 at 2000 metres, all the values being considerably below that quoted above. Hence as far as the present records go, there is no indication that salinity has any great effect upon the distribution of the Pteropoda.

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BRITISH MUSEUM (NATURAL HISTORY)

THE
JOHN MURRAY EXPEDITION
1933–34

SCIENTIFIC REPORTS

VOLUME V. No. 3

CRUSTACEA: PENÆIDÆ

BY

M. M. RAMADAN, PH.D.(CANTAB.)

WITH FIFTEEN TEXT-FIGURES

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM
SOLD BY
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AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W. 7
1938

Price Two Shillings and Sixpence

[*Issued 26th March*, 1938]

DESIGNED AND PRINTED BY
ADLARD & SON LTD.
21, HART STREET, W.C.
AT
BARTHOLOMEW PRESS
DORKING

Made and printed in Great Britain

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INTRODUCTION.

THE material upon which this report is based is primarily the Penæidæ collected by the John Murray Expedition, but I have also examined a number of Penæidæ in the collection of the British Museum, material obtained by the German Deep-Sea Expedition, and other specimens mentioned below. Of the subfamily Aristæinæ, the genera *Benthesicymus* and *Gennadas* are not included in this report, as they will be the subject of a separate report by another author.

I am greatly indebted to Lt.-Col. R. B. Seymour Sewell, C.I.E., F.R.S., for the opportunity of examining this interesting collection, and for securing for me, for examination, specimens of *Aristeus alcocki* (= *Aristeus semidentatus* of Alcock) from the Indian Museum. I wish to express my thanks and gratitude to Dr. W. T. Calman, F.R.S., Keeper of the Zoological Department in the British Museum, for the opportunity of working in his Department, and to Miss I. Gordon, D.Sc., for her help during my work there and for securing for my examination several specimens from other Museums. I also desire to acknowledge my indebtedness to Prof. H. Balss, of the München Museum, for the loan of two specimens of *Aristeus semidentatus*, collected by the German Deep-Sea Expedition; to Dr. J. Richard, Director of the Monaco Museum, for the loan of a specimen of *Aristeus antennatus* collected by the Prince of Monaco; to Mr. M. D. Burkenroad, of the Peabody Museum of Natural History, Yale, for his unfailing courtesy in answering my correspondence; to Dr. Schellenberg, of the Zoologisches Museum der Universität, Berlin, for the provision of facilities for work during my visit to the museum, and for the loan of five specimens of *Aristeus semidentatus* collected by the German Deep-Sea Expedition; and to Mr. Fenner A. Chase, jun., of the Museum of Comparative Zoology, Harvard, for examining for me some material in that Museum.

Finally, I wish to express my grateful thanks to Prof. J. S. Gardiner, F.R.S., in whose laboratory the work was done; and to Dr. L. A. Borradaile for his valuable help and for the great pains he has taken in reading through the text.

List of the Species.

Aristeus alcocki sp. nov.
A. antennatus (Risso).
A. mabahissæ sp. nov.
A. virilis (Spence Bate).
Hemipenæus carpenteri Wood-Mason.
H. crassipes Wood-Mason.
Plesiopenæus armatus (Spence Bate).
Aristeomorpha foliacea (Risso).
P. edwardisianus (Johnson).
Aristeomorpha sp.
Hepomadus tener Smith.
Solenocera hextii Wood-Mason.
S. rathbuni nom. nov.
Hymenopenæus propinquus (De Man).
H. lucassii (Spence Bate).
H. sewelli sp. nov.
H. fattahi sp. nov.
Penæus indicus Edwards.
P. marginatus Randall.
Trachypenæus curvirostris (Stimpson).
Funchalia woodwardi Johnson.
Pelagopenæus balboæ (Faxon).
Penæopsis rectacutus (Spence Bate).
P. coniger (Wood-Mason).
P. serratus (Spence Bate).
P. philipii (Spence Bate).
P. vaillanti Nobili.
P. faouzii sp. nov.
Parapenæus fissurus (Spence Bate).
P. investigatoris Alcock & Anderson.
P. murrayi sp. nov.
Eusicyonia carinata (Olivier).

Subfamily Aristæinæ.

The Aristæinæ comprises two series, the Benthesicymæ and the Aristeæ. The former is characterized by the excessive development of the distal filamentous portion of the superior antennular ramus. The collection of the Benthesicymæ of the Expedition will be reported on by another hand.

Key to the Genera of the Aristeæ.

(Modified from that of Alcock, 1901, pp. 12–13.)

1. No hepatic spine on the carapace.
   A. A well-developed podobranch on the 3rd legs and well-developed epipodite on the 4th leg . . . *Plesiopenæus.*
   B. The podobranch on the 3rd leg and the epipodite on the 4th leg are usually absent, and, if present, are very reduced.
      a. Cervical groove indistinct; no podobranch on the 3rd leg, no epipodite on the 4th leg, no exopodites on the legs . . . . *Aristeus.*
      b. Cervical groove distinct; podobranch on the 3rd leg, epipodite on the 4th leg and exopodites on the legs may be present though reduced . . . . . *Hemipeneus.*
2. An hepatic spine on the carapace.
   A. A well-developed podobranch on the 3rd leg and a well-developed epipodite on the 4th leg. Rostrum armed with more than 3 teeth . . . . *Aristeomorpha.*
   B. The podobranch on the 3rd leg and the epipodite on the 4th leg, if present, are very reduced; rostrum armed with 3 teeth . . . . *Hepomadus.*

Genus *Aristeus* Duv.

Aristeus, Alcock, 1901, p. 29; Bouvier, 1908, p. 69; De Man, 1911, pp. 6 and 27; Balss, 1925, p. 224.

This genus comprises seven, or perhaps eight, species, of which one is new and one is here established for material already known. These species are:

A. antennatus Risso.
A. antillensis Bouvier.

A. occidentalis Faxon.
A. semidentatus Spence Bate, 1888, and de Man, 1911 ; *nec A. semidentatus* Alcock, 1901 ; *A. semidentatus* Kemp & Sewell, 1912 ; Balss, 1925.
A. virilis (Spence Bate) (= *A. tomentosus* (Spence Bate) and *A. semidentatus* Balss, 1925, in part).
A. alcocki sp. nov. (= *A. semidentatus* Alcock, 1901 ; Kemp & Sewell, 1912).
A. mabahissæ sp. nov. (= *A. semidentatus* Balss, 1925, in part).
A. japonicus Yokoya ?.

It is very doubtful whether *A. japonicus* is really an *Aristeus*. Yokoya's figure (1933, p. 3) shows a hepatic spine on the carapace and more than three teeth on the rostrum ; both these characters are diagnostic of the genus *Aristeomorpha* and never occur in *Aristeus*. The key given by Bouvier (1908, p. 70) for *Aristeus* is not quite correct. The presence of a spine on the posterior edge of the 3rd abdominal segment has not the value given to it in the key, as its presence or absence is due to individual variation. Similar spines have been found in some specimens of *A. alcocki* and *A. mabahissæ*, as will be seen later. The post-rostral carina extends beyond the gastric region, contrary to Bouvier, not only in *A. antennatus*, but in all the other species examined by me, though it is very faint beyond the gastric region. Although in *A. antennatus* it is more conspicuous in the region referred to than in the rest of the species, this slight difference cannot be relied on in identification unless specimens of *A. antennatus* are available for comparison. The utilization of the nature of the pleurobranchiæ in advance of segment XIV as a specific character by Bouvier (1908, 1909) is very misleading. Faxon's description of the pleurobranchiæ on the segments in advance of segment XIV in *A. occidentalis* is not exact, as will be shown below. Again, when Alcock described these pleurobranchiæ in *A. semidentatus* as minute filaments with no pinnules, he was in error, as he was dealing with a species (*A. alcocki*) other than *A. semidentatus*.

I have seen specimens of all the species of this genus except *A. antillensis*. Most of the characters given by Bouvier (1909) as separating the latter species from *A. antennatus* are of doubtful value. Some of them, as I have shown under *Plesiopenæus armatus*, must be due to intra-specific variation. If Bouvier's statement (1909, p. 203) regarding the measurements of the segments of the 3rd legs is correct, this species would be easily separated from the rest of the species by having the carpus of the 3rd leg as long as the corresponding merus ; but* this must be admitted with some reservation, since a similar statement by Bouvier concerning another species has proved to be incorrect. Although the relative lengths of the leg segments are commonly used as one of the characters by which species of this genus can be separated from each other, yet these measurements, *per se*, cannot be considered a good specific character, as work on certain other prawns (*e. g. Palæmon carcinus*) has shown that the relative lengths of the leg segments vary with age. Unfortunately the available specimens of the different species of this genus are not of graded sizes, so a study of the growth changes of the relative lengths of the legs could not be made ; but from a study of the measurements of the legs of all the specimens available of *A. virilis, A. alcocki* and *A. mabahissæ*, which species can be easily separated from each other by a number of characters mentioned below, I have reached the conclusion

* Under *A. antennatus*, Bouvier (1908, p. 72) states that the chela of the 3rd leg is as long as the corresponding carpus. On examination of one of the specimens examined by him (see below under *A. antennatus*) that was found not to be true.

that in *adult* specimens of this genus the relative length measurements of the leg segments are constant for each species and are different from those of other species. On this basis the relative length measurements were made use of in order to distinguish *A. antennatus*, of which no male specimens are available. In a specimen of *A. virilis* (180 mm. long) the merus of the 5th leg is 22 mm. long and the carpus is 23 mm.; in a specimen of *A. mabahissæ* (180 mm.) these two segments measure 24 mm. and 24 mm. respectively; while in a smaller specimen of *A. antennatus* (160 mm.) these two segments measure 19 mm. and 26 mm. It will be noticed that in the last specimen, which is smaller than the specimens of *A. virilis* and *A. mabahissæ*, the carpus is longer than in the two specimens of the two latter species. *A. virilis* is easily distinguished by the tomentum on the body and legs, and by having a movable spine on the merus of the three anterior legs. *A. alcocki* is separated by the pleurobranchiæ in advance of segment XIV being the merest papillæ with no pinnules at all, and by the position of the anterior part of the branchio-hepatic groove. The rest of the species can be separated by the relative lengths of the leg segments, as will be seen below under the accounts of individual species.

De Man (1911, p. 36) writes regarding *A. semidentatus* Spence Bate: "This species is very closely related to *A. occidentalis* Faxon from the Galapagos Islands, but in this form the pleurobranchiæ of the somites X–XIII should bear no pinnules at all." I would note here that the description of *A. occidentalis* given by Faxon is, in this respect, not correct. I have examined a female specimen of this species from the Galapagos Islands in the collection of the Museum of Comparative Zoology, Harvard, and I found that the pleurobranchiæ referred to are as well developed as in examples of *A. semidentatus* obtained by the "Challenger" and the "Siboga". These pleurobranchiæ, although much smaller than those on the 14th somite, yet carry many pinnules, and in some of the "Challenger" specimens they carry about 15 on either side. *A. occidentalis* and *A. semidentatus* do not differ in the relative length measurements of the three anterior legs. The 4th legs of the specimen of *A. occidentalis* were missing, and the 5th legs were missing in all the specimens of *A. semidentatus* examined. An exact comparison could not therefore be made; but I would note here that the inner edge of the merus of the 1st leg of the male of *A. semidentatus* ("Siboga" specimen) is concave. Mr. Fenner A. Chase, jun., of the Museum of Comparative Zoology at Harvard, who examined for me the male specimen of *A. occidentalis*, writes: "The merus of the 1st leg is perfectly straight, so that I would hesitate to call it even slightly concave." On this account I am inclined at the moment to consider *A. occidentalis* to be a separate species from *A. semidentatus*. The inner antennular flagellum of the male of *A. occidentalis*, according to the description and a figure by Mr. Chase, is concave for some distance on the inner side and not flattened as in *A. virilis* or *A. mabahissæ* (Text-fig. 4 *c*). The inner antennular flagellum was missing in the male specimen from the "Siboga" Collection. In all the specimens of the genus examined by me a movable spinule was found to exist on the anterior part of the meri of the 1st and 2nd legs and on the first three legs in *A. virilis*. Although I have not seen specimens of *A. antillensis*, these spinules are probably possessed by it, judging by the constancy of their occurrence in all other species.

Distribution.—*A. occidentalis*, Pacific (off Central America); *A. antillensis*, Sea of the Antilles; *A. antennatus* has the widest distributional range of all the species of the genus—Mediterranean, East Atlantic and Indo-Pacific. The greatest depth at which this genus has been observed is 1400 metres (*A. antennatus*). The vertical distribution is variable : *A. antennatus* has been taken at depths between 200 and 1400 m. and *A. alcocki* between 270–360 m., and 1051 m.

Aristeus virilis (Spence Bate).

Aristeus virilis, Spence Bate, 1888, p. 303, pl. 44, fig. 4, Alcock, 1901, p. 30.
Aristeus semidentatus, Balss, 1925, p. 224, in part.

Occurrence.—Sta. 115, Zanzibar area, depth 640–658 m. ; 1 female.

The specimen is 180 mm. long, with the spermatophores intact. To the description of previous authors I may add that the merus of each of the first three legs possesses a movable spinule on the anterior part. These spinules were found to be present in the " Challenger " specimens and in two specimens from the Indian Museum. In the other species of the genus they are present on the first two legs only. This species is easily distinguished from the other species of the genus by the pubescence of the body, the possession of movable spinules on the first three legs and the relative length measurements of the legs. Besides these differences, the males are distinguished from those of other species by the antennular flagellum being concave in the basal part, while beyond the concavity it is flattened. This flattened part does not extend beyond the exopodite.

The following are the measurements of the three anterior legs :

	Merus.	Carpus.	Chela.
1st leg . . .	14 mm. .	12 mm. .	16 mm.
2nd leg . . .	15 mm. .	16 mm. .	17 mm.
3rd leg . . .	15 mm. .	20 mm. .	18 mm.

These relative measurements of the legs were found to be in harmony with those of the " Challenger " material.

From the above it is seen that the chela is longer than the corresponding merus and is longer in proportion to the carpus than in *A. semidentatus* Spence Bate, as is seen by comparing the figures given for the latter (*vide infra* under *A. alcocki*, p. 41). The dactylus, propodus and carpus of the last two legs and the carpus of the first three legs are ornamented with a longitudinal series of small pits, defined with red pigment.

The following are the measurements of the last two legs :

	Merus.	Carpus.	Propodus.	Dactylus.
4th leg. .	20 mm. .	20 mm. .	13 mm. .	10 mm.
5th leg .	22 mm. .	23 mm. .	14 mm. .	..

In the males of this species the scaphocerite is much thickened at the tip and the inner edge of the merus of the 1st leg is straight and not concave.

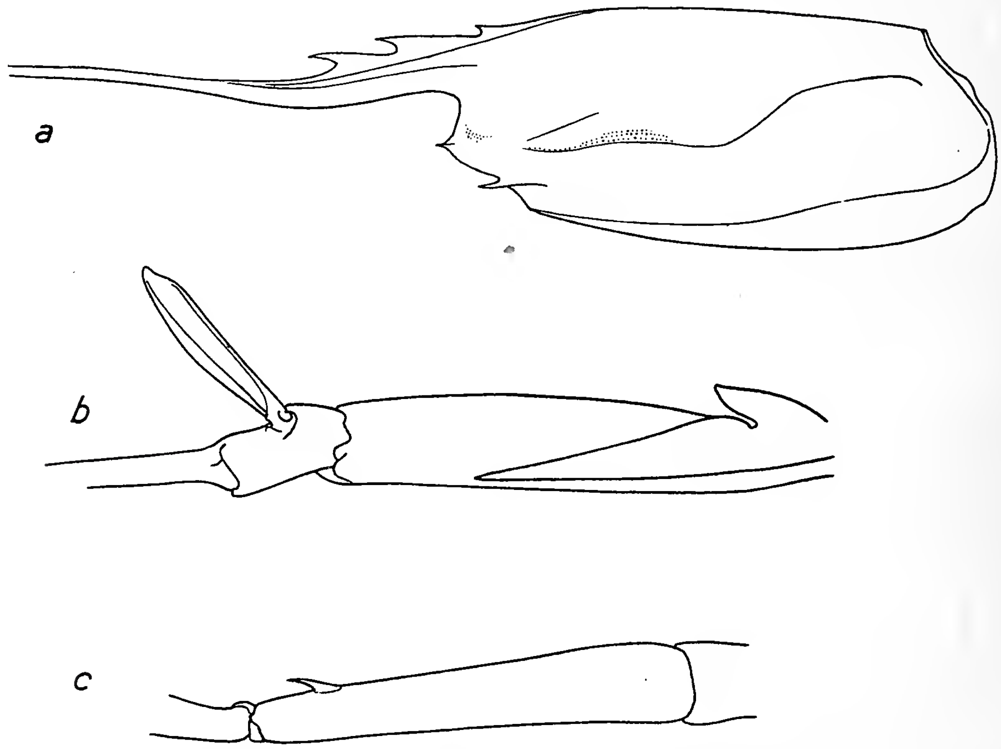
Some of the specimens of the German Deep-Sea Expedition, identified by Balss as " *A. semidentatus* ", have been examined by me. In certain of these (two males from " Valdivia ", Sta. 192, and 1 male and 1 female from Sta. 199) the body is pubescent and the three anterior legs possess a spine on their meri. The scaphocerite and the inner antennular flagellum are as described above, and the measurements of the legs are in harmony with the measurements given above. These specimens, therefore, belong to *A. virilis*.

DISTRIBUTION.—This species is limited to the Indo-Pacific region ; Philippine Islands, New Hebrides, Andaman Sea and Zanzibar area (238–741 m.).

Aristeus alcocki sp. nov. (Text-figs. 1 *a–c* ; 2 *a* and 3 *a*.)

Aristeus semidentatus, Alcock, 1901, p. 31; Illus. Invest. Crust., pt. ix, 1901, pl. 49, fig. 3; Kemp & Sewell, 1912, p. 19. Nec *A. semidentatus* Spence Bate and Balss.

OCCURRENCE.—(1) Sta. 34, Gulf of Aden, depth 1022 m. ; 4 females, 1 male.
(2) Sta. 35, Gulf of Aden, depth 450–550 m. ; 10 females, 8 males.
(3) Sta. 176, Gulf of Aden, depth 650–730 m. ; 2 females.
(4) Sta. 177, Gulf of Aden, depth 270–360 m. ; 3 females.
(5) Sta. 193, Gulf of Aden, depth 1051 m. ; 1 female.



TEXT-FIG. 1.—*Aristeus alcocki* sp. nov. *a*, ♀, carapace. × 1·7. *b*, ♂, basal part of antennular flagellum. × 6. *c*, ♂, merus of 1st walking leg. × 6.

De Man (1911, p. 29), under *A. semidentatus*, writes: "It is with some doubt that these specimens are referred to *A. semidentatus*, because according to Alcock the pleurobranchiæ in advance of segment XIV should be mere little papillæ only visible with a lens." Kemp and Sewell (1912, p. 17), under "*A. semidentatus*", remark: "It would appear doubtful whether the specimens obtained by the 'Siboga' really belong to this species."

On examining the material of the "Challenger" (including the type), the two specimens from the "Siboga" collection, four specimens from the Indian Museum of the material referred by Alcock, Kemp and Sewell to "*A. semidentatus*", and the material of the John Murray Expedition, it was found that the specimens of the "Challenger" and of the "Siboga" are similar and differ from the rest. The difference is not only in the nature of the branchiæ, but in other respects also. For the material obtained by the "Investigator" and described by Alcock, Kemp and Sewell and the material collected by this Expedition a new species has been established and is named after Alcock. This species is separated from *A. semidentatus* by the nature of the branchiæ, the position of the anterior part of the branchio-hepatic groove and the relative length measurements of the legs. In the specimens from the "Challenger" and those from the "Siboga" the pleurobranchiæ on segments X–XIII are not mere papillæ, but are distinct filaments, provided with pinnules, and in some of the "Challenger" specimens these filaments are quite big, while in *A. alcocki* these branchiæ are very minute papillæ, seen only with a lens and possessing no pinnules at all. In *A. semidentatus* (see Spence Bate, 1888, pl. 49, fig. 1) the buttress of the pterygostomian spine is long and the anterior part of the branchio-hepatic groove is straight and lies close to the buttress of the pterygostomian spine. In *A. alcocki* the buttress of the pterygostomian spine is very short but well developed, the branchio-hepatic groove is at a higher level than in *A. semidentatus*, so that there is a wide gap between it and the buttress of the pterygostomian spine, and its anterior part is not straight (Text-fig. 1 *a* ; Illustr. "Investigator", pl. 49, fig. 3).

In *A. semidentatus* the chelæ of the three legs are distinctly shorter in proportion to the carpus than in this species. The following are the measurements of the legs of a female of the former species collected by the "Challenger" at Sta. 171 (carapace length 50 mm., not including rostrum).

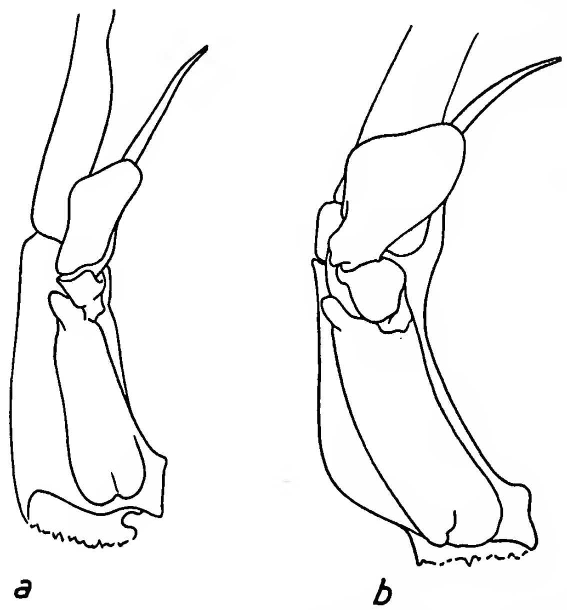
	Merus.	Carpus.	Chela.	
1st leg	18 mm.	14 mm.	15 mm.	
2nd leg	19 mm.	19 mm.	16 mm.	
3rd leg	20 mm.	25 mm.	18 mm.	
	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	24 mm.	26 mm.	16 mm.	7 mm.

The following are the measurements of a female specimen of *A. alcocki* (carapace length 35 mm., not including rostrum).

	Merus.	Carpus.	Chela.	
1st leg	12 mm.	8 mm.	11 mm.	
2nd leg	13 mm.	13 mm.	13 mm.	
3rd leg	14 mm.	18 mm.	14 mm.	
	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	17 mm.	18 mm.	13 mm.	7 mm.
5th leg	16 mm.	18 mm.	14 mm.	7 mm.

From the above measurements it is clear that the chela in *A. alcocki* is longer in proportion to the carpus than in *A. semidentatus*.

The integument is glabrous and polished. The rostrum in the female is longer than the carapace and strongly recurved, and in the male it reaches the end of the antennular peduncle. The post-rostral carina extends beyond the gastric region to just in front of the denticle which exists at the posterior edge of the carapace ; but beyond the gastric region the carina is very faint. The 3rd abdominal segment in two of the females from Sta. 34 ends in a spine. The telson is much smaller than the inner uropod and carries three movable spinules. The 3rd pair of legs just reaches the end of the scaphocerite; the 4th and 5th legs reach a little beyond the end of the scaphocerite. The meri are ornamented with red pits in the same manner as in *A. virilis*. The scaphocerite is very slightly thickened in the male, but not to the same extent as in *A. virilis*. In the male the inner antennular flagellum is very slightly twisted beyond the end of the exopodite and is notched but not flattened (Text-fig. 1 *b*). I am unable to find any difference between the males of this species and *A. semidentatus* in this respect, as the single male in the "Challenger" Collection is very young and the male specimen from the "Siboga" collection has the flagellum broken. The male of this species, however, is distinguished



TEXT-FIG. 2.—Appendix masculina of *a*, *Aristeus alcocki* n. sp. *b*, *A. mabahissæ* n. sp. × 6.

from that of *A. semidentatus* by having the inner edge of the merus of the 1st leg straight, while in the latter species it is concave ("Siboga" specimen). The two ultimate segments of the 3rd maxillipeds differ in the two sexes; in the female the propodus is of the same shape as the carpus, and gradually tapers distally, and the dactylus just exceeds half the length of the propodus; in the male the propodus is of a different shape and extends on the outer side beyond the insertion of the dactylus; it is flattened both on its outer side anteriorly and on its ventral side posteriorly, and the dactylus is three-quarters as large as the propodus. The appendix masculina and petasma are shown in Text-figs. 2 *a* and 3 *a*. The width of the petasma is more than half the length.

The average length of the females of the species is 140 mm., and of the males 110 mm., both measured from the tip of the rostrum to the end of the telson. This species is, on the whole, smaller in size than the other species of the genus, as females of the above length were sexually mature and were carrying spermatophores.

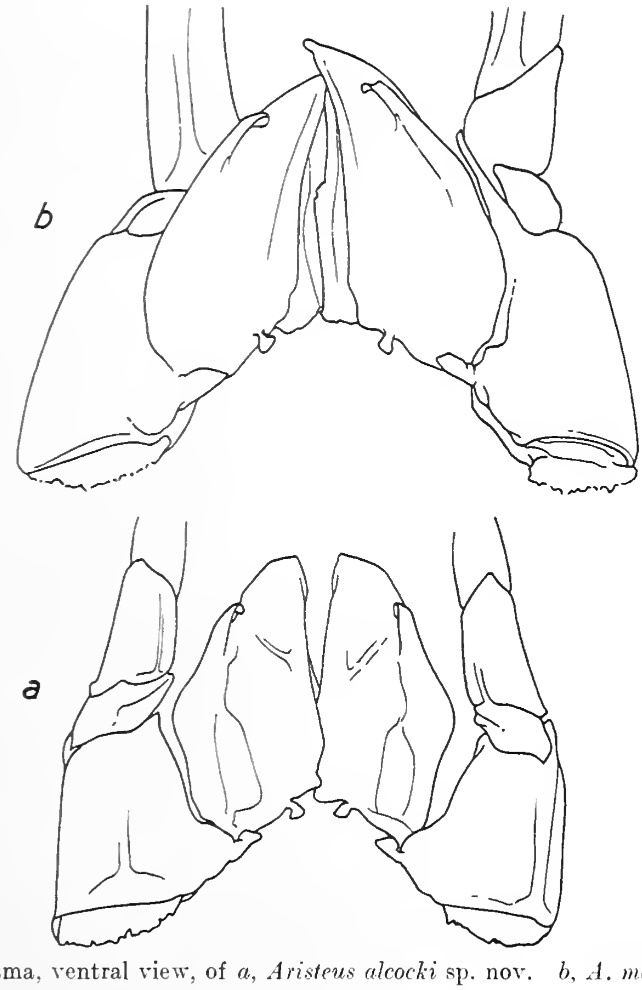
DISTRIBUTION.—Gulf of Aden, Arabian Sea (near Laccadives and Cape Comorin) and Bay of Bengal (270–1022 m.).

Aristeus mabahissæ sp. nov. (Text-figs. 2 *b*, 3 *b* and 4 *a–c*.)

Aristeus semidentatus, Balss, 1925, p. 224, in part.

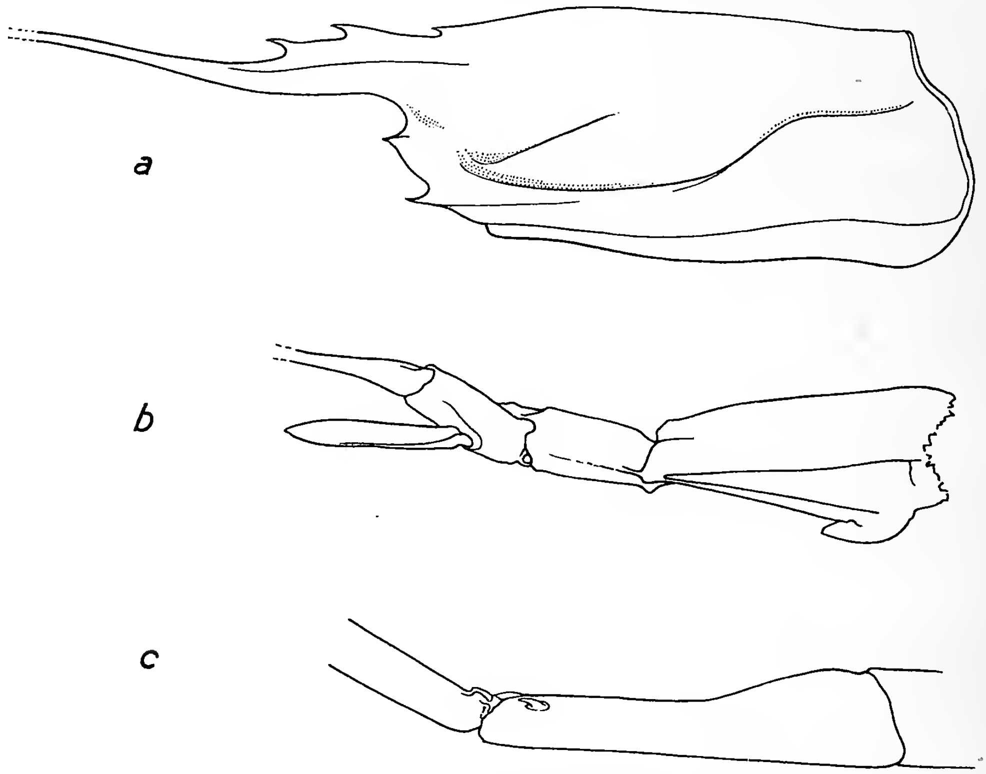
OCCURRENCE.—(1) Sta. 143, Maldive area, 795 m. : 2 females.
(2) Sta. 145, Maldive area, 510 m. : 2 females, 2 males.

This species is closely related to *A. semidentatus* Spence Bate. In the nature of the pleurobranchiæ in advance of segment XIV and in the position of the anterior part of the



TEXT-FIG. 3.—Petasma, ventral view, of *a*, *Aristeus alcocki* sp. nov. *b*, *A. mabahissæ* n. sp. × 5.

branchio-hepatic groove and in general shape of the body the two species do not differ. The integument is glabrous and polished. The rostrum is strongly recurved in the female and slightly so in the male ; in the three adult females the tip of the rostrum is broken, but the rostrum is at least as long as the carapace ; in the male it reaches beyond the antennular peduncle. The post-rostral carina is faint beyond the gastric region, and extends, as in *A. alcocki*, to just in front of the denticle at the posterior edge of the carapace (Text-fig. 4 *a*). In one male and one female the 3rd abdominal segment carries a spine medially on its posterior edge. The last three abdominal segments are sharply carinate and end in spines. The telson is shorter than the inner rami of the uropods and carries three movable spines. The merus of the 1st and 2nd legs carries a movable spinule. In the female the 3rd legs reach the end of the scaphocerite, but are shorter in the male. The 2nd leg reaches beyond the spine of the scaphocerite, and the 1st leg reaches the end of the external maxillipeds. This species is easily distinguished from *A. semidentatus* by the measurements of the legs. The chelæ of the legs are longer in proportion to the carpus than in the latter species, but not as long as in *A. virilis* or *A. alcocki*; the last two legs differ in their measurements from any other species in the genus.



TEXT-FIG. 4.—*Aristeus mabahissæ* n. sp. *a*, ♀, carapace, × 1·3. *b*, ♂, basal part of antennular flagellum, × 3·3. *c*, ♂, merus of 1st walking leg, × 4·7.

The following are the measurements of the legs of a female (total length 180 mm.):

	Merus.	Carpus.	Chelæ.
1st leg	16 mm.	12·5 mm.	15 mm.
2nd leg	17 mm.	18 mm.	17 mm.
3rd leg	18 mm.	24 mm.	17 mm.

	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	24 mm.	21 mm.	13 mm.	8 mm.
5th leg	24 mm.	24 mm.	14 mm.	9 mm.

On comparing the measurements given above with those given for *A. semidentatus* and *A. alcocki* the difference is clearly seen. The same relative lengths are found in the male. In the male the inner antennular flagellum is very much twisted beyond the exopodite and the twisted part is very flattened (Text-fig. 4 *b*). The general shape of the flagellum recalls that of *A. virilis*, but in the latter species the basal part is concave on the inner side and the twisted flattened part does not extend beyond the end of the exopodite, while in this species it starts beyond the end of the exopodite (Text-fig. 4 *b*). The scaphocerite of the male is slightly thickened at the tip and the merus of the 1st leg is deeply concave on the inner side (Text-fig. 4 *c*). The propodus of the external maxilliped is not modified, as it is in *A. alcocki*. The appendix masculina and petasma are as shown in Text-figs. 2 *b* and 3 *b*, and their differences from *A. alcocki* will be best seen by comparing the figures ; in the petasma the length is about twice the breadth, while in *A. alcocki* it is decidedly less than twice the breadth. The legs are ornamented in the same way, but not as much, as in the other species. On the whole, the females of this species are separated from other species by the relative measurements of the legs, and the males by the shape of the antennular flagellum and the concavity on the inner edge of the 1st leg.

To this species belongs a female of the German Deep-Sea Expedition, identified by Balss as "*A. semidentatus*", taken at "Valdivia" Sta. 192. The measurements of the legs were found to be in harmony with the figures given above and the specimen was taken near the Maldives, as were the specimens obtained by the John Murray Expedition. The two females from Sta. 145 and one from Sta. 143 are adults, as they carry spermatophores and measure about 180 mm. ; the two males measure about 130 mm. One of the two females from Sta. 143 is very small.

Aristeus antennatus Risso.

Aristeus antennatus, Bouvier, 1908, pp. 71–75, pl. iii, figs. 2, 3 ; pl. xi, figs. 7–14 ; pl. xii.

OCCURRENCE.—(1) Sta. 109, Zanzibar area, depth 640 m. ; 1 female.

(2) Sta. 115, Zanzibar area, depth 640–658 m. : 2 females.

(3) Sta. 122, Zanzibar area, depth 732 m. ; 1 female.

(4) Sta. 143, Maldive area, depth 770 m. ; 1 female.

Bouvier's description of this species is very vague. He concentrated on comparing this species with *Plesiopenæus edwardisianus*. Such comparison between two species of different genera will naturally reveal many differences, but their value in defining the exact position of the species among its congeners is useless. His description can be applied to almost any other species of the genus. In his discussion of the affinities of the species, Bouvier mentions that the presence of the post-rostral carina beyond the gastric region, the presence of a small spine on the posterior edge of the 3rd abdominal segment and the sexual dimorphism exhibited by the 3rd maxillipeds are characters which distinguish this species from the others. In the light of our present knowledge of the other species of the genus, these characters are of no practical value in diagnosing *A. antennatus*. The post-rostral carina extends beyond the gastric region in all the other species examined by me, though only faintly in *A. antennatus*. The presence or absence of a denticle at the posterior edge of the 3rd abdominal segment cannot be considered a specific character, as this feature is subject to intra-specific variation ; such denticles or spines are present in some specimens of *A. alcocki* and *A. mabahissæ*. Sexual differences in the last two segments of the 3rd maxillipeds occur in other species of the genus, and in *A. alcocki* they are as developed as described by Bouvier for *A. antennatus*.

Before I saw any specimens from Bouvier's material I had already established a new species for the material of this expedition on the grounds of geographical distribution and on the relative lengths of the leg segments. I have since been able to examine the female specimen collected by the late Prince Albert of Monaco at Sta. 1114 (depth 851 m.), the measurements of which are given by Bouvier (1908, p. 74) and which is figured on pl. iii and pl. xi. Bouvier (1908, p. 72) writes that the chela of the 3rd leg is equal to the carpus—a statement which neither agrees with his figure nor with the measurements of the 3rd leg of the actual specimen. I give below a description of this species. Bouvier's specimen, which is the largest collected by the Prince of Monaco, is 175 mm. long. The largest specimen taken by the John Murray Expedition is 190 mm. long (Sta. 115) and the smallest is 150 mm. (Sta. 109).

The body is glabrous and the branchio-hepatic groove is very clear, contrary to Bouvier's figure. In the smallest specimen taken by the John Murray Expedition it is not so marked as in the large specimens. The anterior part of the branchio-hepatic groove is at the same level as the pterygostomian spine, as in *A. semidentatus* and *A. mabahissæ*. The post-rostral carina extends beyond the gastric region to just in front of the posterior end of the carapace, but it is faint beyond the gastric region. The pleurobranchiæ in advance of segment XIV, though not as big as that on the XIVth, are plumose. The merus of both the 1st and 2nd legs carries a movable spinule anteriorly. The 3rd abdominal segment in Bouvier's specimen, as in all the other specimens, carries a small spine posteriorly, and the last three segments are carinate and end in spines. In Bouvier's specimen the 1st leg reaches the end of the 2nd segment of the antennular peduncle, the 2nd leg reaches the end of the antennular peduncle, the 3rd leg does not quite reach the end of the scaphocerite, the 4th leg reaches beyond the scaphocerite by more than half the dactylus. This reach of the legs applies to the small specimen taken at Sta. 109, but in the large specimen taken at Sta. 115, the 2nd pair of legs reaches the end of the squame and the 3rd reaches beyond the squame by half the dactylus, the 4th by the whole dactylus, and the 5th pair by the dactylus and a part of the propodus.

The following are the measurements of the legs of Bouvier's specimen (total length 175 mm.):

	Merus.	Carpus.	Chela.
1st leg	16 mm.	11·5 mm.	15 mm.
2nd leg	16 mm.	16 mm.	18 mm.
3rd leg	17·5 mm.	21 mm.	18 mm.

	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	21 mm.	14 mm.	14 mm.	..
5th leg	20 mm.	28 mm.	17 mm.	8·5 mm.

The following are the measurements of the legs of the large specimen taken at Sta. 115 (total length 190 mm.):

	Merus.	Carpus.	Chela.
1st leg	19 mm.	13 mm.	18·5 mm.
2nd leg	19·5 mm.	19 mm.	21·5 mm.
3rd leg	21 mm.	26 mm.	21·5 mm.

	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	26 mm.	27·5 mm.	15 mm.	12 mm.
5th leg	24 mm.	31 mm.	..	..

It will be seen that the measurements of the legs of these two specimens are proportionally in close agreement, and that in this species the chela of each of the anterior three legs are much longer in proportion to the carpus than in *A. semidentatus* and *A. mabahissæ*, and that the carpi of the 4th and 5th legs are enormously longer in proportion to the meri than in *A. mabahissæ*. The exceptional length of the carpus of the 5th pair would easily differentiate this species from the others.

The ornamentation of the legs in this species is different from the others. In the large specimen from Sta. 115 and in the specimen from Sta. 122, the pittting of the legs is so close that it gives the impression of a continuous red line. In the other smaller specimens the pitting is not so close and in the Monaco specimen the pigment has disappeared.

To this species belong two female specimens of the German Deep-Sea Expedition, taken at "Valdivia" Sta. 251 and Sta. 254, which were identified by Balss as *A. semi dentatus*. These specimens were taken at almost the same locality as those of the John Murray Expedition, namely, on the East African coast. In both specimens the 3rd abdominal segment carries a spine medially on the posterior edges. Both specimens are 160 mm. long, and the following are the measurements of the legs of the specimen from Sta. 254 (carapace 78 mm. including rostrum):

	Merus.	Carpus.	Chela.	
1st leg	15 mm.	11·5 mm.	15 mm.	
2nd leg	16 mm.	16 mm.	18 mm.	
3rd leg	17 mm.	21 mm.	18 mm.	
	Merus.	Carpus.	Propodus.	Dactylus.
4th leg	21 mm.	23 mm.	13·5 mm.	9 mm.
5th leg	19 mm.	26 mm.	16 mm.	9·5 mm.

These figures are proportionally in agreement with those given above. It will be noticed that the carpus of the 5th leg in this small specimen is actually longer than the corresponding joint in the large specimen of *A. mabahissæ* (180 mm. long).

I have not seen any male specimens of this species.

DISTRIBUTION.—Mediterranean, East Atlantic Ocean and Indo-Pacific Ocean (Zanzibar area) (200–1400 m.).

Genus *Hemipenæus* Spence Bate.

Alcock, 1901, p. 31 ; De Man, 1911, p. 23 ; Balss, 1925, p. 223 ; Burkenroad, 1936, p. 90.

According to Alcock and Bouvier, *Aristeus* is distinguished from *Hemipenæus* by the reduction of the pleurobranchiæ in advance of the last thoracic segment and the absence of the cervical groove. As was shown under *Aristeus* (*vide supra*, p. 37), the pleurobranchiæ referred to above are not, as a rule, reduced, as is stated by most authors. The cervical groove in all the examples of the species of *Hemipenæus* examined by me is conspicuous by contrast with the indistinct groove of *Aristeus*. Burkenroad (1936, p. 90) states that in the specimens of *Hemipenæus spinodorsalis* Spence Bate contained in the collection of the Museum of Comparative Zoology, Harvard, the cervical groove is extremely faint. I have found, however, that the groove is conspicuous in the examples of the species in the collection of the British Museum. The fact that the pleurobranchiæ in advance of the last thoracic segment are not reduced, as they were supposed to be,*

* Alcock had only specimens of *Aristeus alcocki* for examination, and in that species the pleurobranchiæ referred to are mere papillæ (*vide supra*, p. 37).

and that the cervical groove is extremely faint in some specimens of *H. spinodorsalis*. makes the separation of these genera less sharp than was implied by Alcock. Burkenroad examined Faxon's material of *H. triton* Faxon and *H. spinodorsalis*, contained in the collection of the Museum of Comparative Zoology, Harvard, and found a podobranch on the 12th somite and an epipodite on the 13th somite in both these two species. He also found small exopodites on the legs. I have been able to confirm Burkenroad's observation of the presence of these structures in specimens of *H. spinodorsalis* in the collection of the British Museum, in a specimen of *H. triton* from the Museum of Comparative Zoology, Harvard, and in another specimen of this latter species collected by the Murray Expedition. Spence Bate's statement (1888, p. 300) that a podobranch occurs on the 12th somite and an epipodite on the 13th somite in *Hemipenœus*, together with his own observations on the two above-mentioned species, led Burkenroad to consider these structures as distinguishing *Hemipenœus* from *Aristeus*. But Burkenroad did not examine any material of *H. crassipes* Wood-Mason, *H. sibogæ* De Man, *H. speciosus* Spence Bate, or *H. gracilis* Spence Bate. *H. crassipes* and *H. sibogæ* possess no podobranch on the 12th somite, no epipodite on the 13th somite and no exopodite on the legs. The same observations apply to the specimens of *H. gracilis* and *H. speciosus* in the British Museum ; but these specimens are not in very good condition, and the fact that these structures in question are minute, when they occur, makes me unable to deny absolutely the occurrence of these structures in these two species. It is, however, evident that the branchial formula as given by Burkenroad is not representative of the genus.

This genus at present contains six species : *H. carpenteri* Wood-Mason (= *H. triton* Faxon), *H. spinodorsalis* Spence Bate, *H. speciosus* Spence Bate, *H. gracilis* Spence Bate, *H. sibogæ* De Man and *H. crassipes* Wood-Mason. I have examined the types of the first five species ; the last is represented in the present collection by seven specimens. In all the species, except *H. carpenteri* and *H. spinodorsalis*, the merus of the 1st and 2nd legs is armed with a spinule, similar to that described in all the *Aristeus* species examined. These two species are also easily distinguished from the rest of the genus by a number of characters which may entitle them to a subgeneric recognition : (1) They possess a spine at the end of the carina of the 4th abdominal segment ; (2) the three anterior legs have a much longer carpus than the other species, and their meri are not flattened ; (3) they possess a podobranch on the 12th somite, an epipodite on the 13th and exopodites on all the legs. *H. carpenteri* is separated from *H. spinodorsalis* by its short rostrum. Of the other four species, *H. speciosus* stands apart by the possession of a post-rostral carina which extends to the posterior region of the carapace, while *H. sibogæ* is distinguished from the remaining two species by the legs being covered with microscopical spinules. De Man (1911, p. 26) writes : " *H. gracilis* Spence Bate may be identical with this species (*H. sibogæ*) or with *H. crassipes*." I would note that *H. gracilis* is easily distinguished from the two other species under consideration by the brown colour of the eyes, which are black in the other two species,* and again from *H. sibogæ* by the absence of the microscopical spinules on the legs and by the dense tomentum of the body. The body of *H. gracilis* is slightly tomentose as that of *H. crassipes*, from which it is easily distinguished by the colour of the eyes.

DISTRIBUTION.—*Hemipenœus carpenteri* : American Pacific, American Atlantic and

* This difference may be due to fixation and preservation, and may not hold in living specimens.

Indo-Pacific regions (1650–3872 m.) *H. spinodorsalis* : American Pacific, South Atlantic and Indo-Pacific regions (1867–3749 m.). *H. speciosus* : Atlantic Ocean (East of Buenos Ayres, 4847 m.). The other three species are limited to the Indo-Pacific area ; *H. gracilis* (1280 m.), *H. crassipes* (500–1737 m.) and *H. sibogæ* (1000 m.).

Hemipenæus crassipes (Wood-Mason).

Hemipenæus crassipes, Alcock, 1901, p. 33 ; Illus. Invest. Crust., pt. ix, 1901, pl. 49, figs. 1, 2 ; De Man, 1911, p. 24 ; Kemp and Sewell, 1912. p. 17, pl. 1, figs. 8 and 9.

Occurrence.—(1) Sta. 33, Gulf of Aden, depth 1295 m. ; 1 female.

(2) Sta. 184, Gulf of Aden, depth 1270 m. ; 1 female.

(3) Sta. 193, Gulf of Aden, depth 1060 m. ; 6 females.

The specimens agree with the cited descriptions and figures except in the following : The meri of the 1st and 2nd legs carry a movable spinule. The eye-tubercles, contrary to Alcock's statement, are rather prominent, as described by De Man. From De Man's (1911) description the specimens differ in having the first pair of legs reaching beyond the antennular peduncle, the second pair reaching beyond the scaphocerite by half the length of the dactylus, and the third pair by the whole length of the finger. There are no podobranchiæ on the third pair of legs, no epipodites on the fourth pair and no exopodites on any of the legs.

Distribution.—Arabian Sea, Malabar Coast, Gulf of Manaar, Bay of Bengal, Andaman Sea, Flores Sea and Makassar Straits (500–1737 m.).

Hemipenæus carpenteri Wood-Mason.

Hemipenæus carpenteri, Wood-Mason, 1891, p. 189 ; Alcock, 1901, p. 32 ; Illus. Invest. Crust., pt. ix, 1901, pl. 49, fig. 4.
Hemipenæus triton, Faxon, 1893, p. 215, 1895, p. 202.
Hemipenæus carpenteri, Burkenroad, 1936, p. 91.

Occurrence.—Sta. 171, central part of the Arabian Sea, depth 3840–3872 m. ; 1 female.

This specimen, which is 175 mm. long, has been compared with one of the types of *H. triton* Faxon ("Albatross", Sta. 3374, depth 1823 m.), and has been found to be identical with it, agreeing in every detail. In this specimen there is a podobranch on the 3rd leg and an epipodite on the 4th. All the legs are provided with minute exopodites. I have not seen the type of *H. carpenteri*, and I follow Burkenroad in synonymizing *H. triton* with *H. carpenteri*.

Distribution.—American Pacific region, American Atlantic region and Indo-Pacific area (Arabian Sea and Bay of Bengal) (1650–3872 m.).

Genus *Plesiopenæus* Spence Bate.

Plesiopenæus, Alcock, 1901 ; Bouvier, 1908 ; De Man, 1911 ; Burkenroad, 1936.
Aristeus (part), Spence Bate, 1888 ; Wood-Mason and Alcock, 1891 ; Faxon, 1895.
Aristeopsis, Wood-Mason and Alcock, 1891 ; Alcock, 1901 ; Bouvier, 1908 ; De Man, 1911.

Species of this genus are easily distinguished by the absence of a hepatic spine on the carapace, the possession of a well-developed podobranch on segment XII and a well-developed epipodite on segment XIII.

Burkenroad's statement that they possess exopodites on the walking legs is not quite correct, as *P. edwardisianus* (Johnson) does not possess any such structures.

The name *Plesiopenæus* was provisionally proposed by Spence Bate (1888, p. 881) for forms related to *Aristeus* with an epipodite on the 13th somite. *Aristeus armatus* Spence Bate and *Aristeomorpha foliacea* (Risso) are the species discussed by Spence Bate (1888), which possess a well-developed epipodite on the 13th somite. In 1891 the genus *Aristeopsis* was established by Wood-Mason and Alcock (p. 284) with *Penæus edwardisianus* Johnson as the genotype, and to this genus they also referred *Aristeus armatus* Spence Bate. In 1895 Faxon (p. 199) designated *Aristeus armatus* Spence Bate as the genotype of Spence Bate's genus *Plesiopenæus.* Six years later Alcock (1901) transferred *Penæus edwardisianus* Johnson to *Plesiopenæus* Spence Bate, leaving *Aristeus armatus* Spence Bate as the only species of *Aristeopsis* Wood-Mason & Alcock. The reason for Alcock's action is obscure. It is clear from the above, as has been explained by Burkenroad (1936), that Alcock's action is the reverse of that necessitated by the history of the two species ; *Aristeus armatus* Spence Bate should be referred to the genus *Plesiopenæus* and *Penæus edwardisianus* Johnson to *Aristeopsis.* But Burkenroad (1936, p. 95) has synonymized *Aristeopsis* with *Plesiopenæus* on the grounds of similarity of the species referred to the two genera by previous authors.

Burkenroad's action is quite justified, and it seems that *Plesiopenæus coruscans* (Wood-Mason) is more nearly related to *Aristeopsis armatus* (Spence Bate) than to *Plesiopenæus edwardisianus* (Johnson), as will be shown below. The distinctions between *Plesiopenæus* and *Aristeopsis* as given by Alcock are (1) that the exopodite of the 2nd maxillipede is much longer than the endopodite in the former genus, and much shorter and slender in the latter, and (2) that the pleurobranchiæ in advance of the 14th segment are reduced in *Plesiopenæus*, while they are of normal size in *Aristeopsis.* Bouvier (1908, p. 187), in his key, states that *Aristeopsis* possesses exopodites on the walking legs, while *Plesiopenæus* does not. This statement is not correct. Bouvier did not see any specimens of *P. coruscans*, in which species Burkenroad has found small exopodites. The presence of exopodites in this species must have been overlooked by Alcock owing to the reduced size of these structures, and he has also overlooked their presence in *P. edwardisianus*, where they occur as stated by Bouvier, Burkenroad, and confirmed by myself. It is true that the pleurobranchiæ in advance of segment XIV are reduced in comparison with those on segment XIV, as stated by Alcock, in *P. cruscans* and *P. edwardisianus*. Burkenroad states that in his specimen of *P. coruscans* the pleurobranch on segment XIII is 10·5 mm. long, as compared with one of 18 mm. on the 14th segment. In a specimen of *P. edwardisianus* (carapace length 60 mm.) the pleurobranch on segment XIII is 7 mm. and that on segment XIV is 14 mm. In a specimen of *Aristeopsis armatus* (carapace length 55 mm.) the pleurobranchs on segments XIII and XIV are of equal length—9 mm. These measurements are in agreement with Alcock's statement ; but a mere reduction in the size of the pleurobranch, which, although small, is yet richly plumose, cannot be considered to be a valid generic character, particularly when there are no other distinctions between the species discussed. In the genus *Aristeus* the pleurobranchiæ of *A. alcocki* in advance or segment XIV are the merest rudiments, being minute papillæ with no pinnæ at all. The other distinctive character by which Alcock separates *Plesiopenæus* and *Aristeopsis* is not clear cut, as may be implied by Alcock's statement. There seems to be a gradual change in this respect from *P. edwardisianus* through *P. coruscans* to *Aristeopsis armatus.*

The exopodite of the 2nd maxillipede of *P. edwardisianus* is twice as long as the endopodite Burkenroad, 1936, p. 95), and in *Aristeopsis armatus* it is considerably shorter. In some respects *P. coruscans* (Wood-Mason), as I have already mentioned, is more nearly related to *P. armatus* than to *P. edwardisianus* ; the two former species both possess exopodites on the walking legs, mobile spines on the meri of some of the walking legs (in *P. coruscans* in the 1st leg only and in *P. armatus* in the first two), and in both the ocular peduncle is flattened and the ocular tubercle well developed. *P. edwardisianus* is distinguished from both *P. coruscans* and *P. armatus* in having the first five abdominal terga carinate (*P. coruscans* has the last three terga carinate and *P. edwardisianus* the last four terga), and in having the outer antennal flagellum in the male produced in the form of a fleshy flagellum. On the other hand, *P. edwardisianus* and *P. armatus* resemble each other in having the terminal joint of the mandibular palp triangular with the inner edge concave, and in having the postero-lateral angles of the last four abdominal pleura mucronate.

DISTRIBUTION.—*P. coruscans*, American Atlantic and Indo-Pacific regions (1026–1650 m.) ; *P. edwardisianus*, American Atlantic, Eastern Atlantic and Indo-Pacific regions (550–1850 m.) ; *P. armatus*, north and south Atlantic Ocean (750–5400 m.). None of the species of this genus occurs in the Mediterranean or in the American Pacific area.

Plesiopenæus edwardisianus (Johnson).

Plesiopenæus edwardisianus, Alcock, 1901, p. 36 ; Bouvier, 1908, p. 64, pl. 2, figs. 13–17, pl. 14, figs. 1–8 ; Burkenroad, 1936, p. 96.
Aristæopsis edwardisiana, Alcock, 1892, Illust. Zool. Invest. Crust., pt. i, pl. 1, figs. 1 and 2.

OCCURRENCE.—Sta. 124, Zanzibar area, depth 913 m. ; 2 females, 1 male.

Plesiopenæus armatus (Spence Bate).

Aristeus armatus, Bate, 1888, p. 312, pls. 45, 46.
Aristeus tridens, Smith, 1884, p. 404, pl. ix, figs. 1–6.
Plesiopenæus armatus, Faxon, 1895, p. 199.
Aristæopsis armatus, Alcock, 1901, p. 41 ; Bouvier, 1905, p. 983 ; 1909, p. 197.
Aristeopsis armatus var. *tridens*, Bouvier, 1908, p. 62, pl. 11, fig. 6 ; 1909, p. 197, pl. 1, figs. 4–7, text-figs. 20–37.
Aristeopsis tridens, Sund, 1920, p. 31.
Plesiopenæus armatus, Burkenroad, 1936, p. 96.

OCCURRENCE.—Sta. 118, Zanzibar area, depth 1789 m. ; 1 female, 1 male.

The female specimen is 140 mm. long ; the male is a little shorter. Bouvier (1909) gives a number of characters by which this species is separated from the var. *tridens*. Sund, on the basis of the characters given by Bouvier, gave the variety specific rank. Burkenroad, however, remarks that several of the characters utilized by Bouvier are of no value. I examined the type-specimens of this species in the "Challenger" collection, and one female specimen of *P. armatus* var. *tridens* from the American Atlantic region in the collection of the Museum of Comparative Zoology, Harvard. The result of this examination led to the conclusion that both forms belong to the same species. The characters utilized by Bouvier for separating the species from the variety are given and discussed on p. 52.

	P. armatus.	*P. armatus* var. *tridens.*
Rostrum	Strongly curved, S-shaped, the teeth are equally sloping; the median one is smaller than the distal one.	Little raised, nearly straight, the first and third teeth are more sloping than the middle one, which is the longest.
Stylocerite	Reaches only the end of the 2nd segment of the antennular peduncle.	Surpasses the end of this segment.
Male scaphocerite	Thickened at the distal end.	Not thickened at the distal end.
Exopodite of 2nd maxillipede	Very reduced, much shorter than merus of endopodite.	Equals $\frac{2}{3}$ the length of the merus in the type var., reaches to the last $\frac{1}{4}$ in the specimen of the "Princess Alice", and to the end in the specimens of the "Blake" and "Talisman".
Telson	Equals the endopodite of the uropods.	Much longer than the endopodite of the uropods.
Infero-posterior angle of the 6th abdominal segment	Only an obtuse tooth.	Occupied by a sharp tooth surmounted by an obtuse lobe.

Bouvier adds that there may be other differences in the shape of the epistome or the petasma. Burkenroad adds another difference overlooked by Bouvier, namely, that the exopodite of the 1st pleopod is given by Alcock and figured by Spence Bate as being not much longer than the first four abdominal terga, whereas according to Smith in a specimen of his this appendage is as long as the first five abdominal terga. Before discussing each of the characters given by Bouvier I would note that the discussion is not based on the text or figures of previous authors, but on the examination of the material of the "Challenger", the two specimens of the Murray Expedition and one female specimen of the variety from the American Atlantic region.

Rostrum.—In most of the specimens it curves upwards to some extent and the teeth are sometimes equally sloping, but there is no constant relation between the sloping of the teeth and the curvature of the rostrum. In a female specimen from the "Challenger", Sta. 276, Low Archipelago, the rostrum is straight and does not rise at all.

Stylocerite.—In all the specimens of the "Challenger", except one, it does not surpass the end of the 2nd antennular segment; the same is the case in the example of the variety. In the same exceptional specimen of the "Challenger" from Sta. 276, referred to above, the stylocerite surpasses the end of the 2nd antennular segment and almost reaches the end of the 3rd.

Scaphocerite.—Of the three males collected by the "Challenger", that from Sta. 184 (near Torres Straits) and that from Sta. 323 the scaphocerite does not show any thickening at all. In that from Sta. 333 it is slightly thickened. In the male collected by the Murray Expedition it is not thickened at all. Bouvier himself writes that the scaphocerite is slightly thickened in one of the "Blake" specimens, referred by him to the variety. It is thus very obvious that this character cannot be given much importance.

Exopodite of the 2nd maxillipede.—Contrary to Spence Bate's, Alcock's and Bouvier's descriptions, I found that the exopodite in the "Challenger" specimens is at least half as long as the meropodite. In three cases it extends beyond the end of the merus. At the same time in the variety, where it should be at least three-quarters the length of the merus, it just reaches beyond the middle of the segment.

Telson.—In none of the specimens examined does the telson reach the end of the endopodite of the uropod.

Infero-posterior angle of the 6th abdominal segment.—As noted by Burkenroad, Bate's figure is incorrect in not indicating a tooth in this position. The tooth is present in all the specimens examined.

Epistome.—The shape of this region is very variable, and the different shapes it exhibits may be due to shrinkage during fixation of the animals.

Exopodite of the 1st pleopod.—In most cases it is less in length than (only in two cases does it equal) the first five abdominal terga. It is very clear from the above that not a single character of Bouvier's holds good and that all the characters are variable. I would note that one of the specimens referred by Spence Bate to *A. armatus* possesses three characters which, according to Bouvier, are diagnostic of the variety. This female specimen was taken at "Challenger" Sta. 276, Low Archipelago (Pacific); it has the rostrum straight, the stylocerite surpassing the end of the 2nd antennular segment, and the exopodite of the 1st pleopod as long as the first five abdominal terga. But this specimen is still young (carapace length 20 mm.), and these characters may possibly change with age.

From the above considerations *P. armatus* and *P. armatus* var. *tridens* must be considered as synonyms.

Distribution.—North and South Atlantic and Indo-Pacific regions (750–5400 m.).

Genus *Aristeomorpha* Wood-Mason.

Alcock, 1909, p. 38; Calman, 1925, p. 7.

Together with *Hepomadus* this genus is separated from the rest of the genera of the Aristæinæ by the possession of a hepatic spine on the carapace. From *Hepomadus* it is distinguished by the possession of a well-developed podobranch on the 12th somite and a well-developed epipodite on the 13th somite. When these two structures are present in *Hepomadus* they are very reduced (see *Hepomadus*, p. 55). *Aristeomorpha* also lacks the movable spine that is present on the meri of the 1st and 2nd legs in *Hepomadus* and other genera. This genus comprises two species, *A. foliacea* (Risso) and *A. wood-masoni* Calman. They are separated by a number of characters given by Calman (1925, p. 8). *Aristeus japonicus* Yokoya (1933) is probably identical with *A. foliacea*.

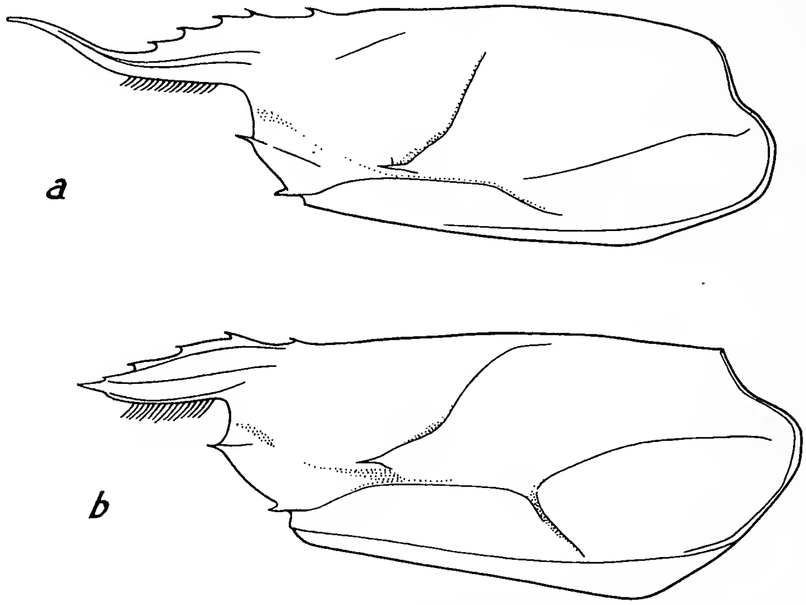
Distribution.—*A. foliacea* occurs in the Mediterranean, East Atlantic Ocean, and ranges the Indo-Pacific Ocean from the East African coast to Japan. *A. wood-masoni* occurs in the Andaman Sea.

Aristeomorpha foliacea (Risso). (Text-fig. 5 *b*.)

Aristeomorpha foliacea, Bouvier, 1908, p. 53, pl. iii, fig. i; pl. xii, figs. 1–5; Kemp and Sewell, 1912, p. 18, pl. i, fig. 5; Calman, 1925, p. 7.
? *Aristeus japonicus*, Yokoya, 1933, p. 3.
[Nec *A. rostridentata*, Alcock, 1901, p. 39; Kemp and Sewell, 1912, p. 17, pl. i, fig. 6.]

Occurrence.—(1) Sta. 115, Zanzibar area, depth 640–658 m.; 28 males, 23 females. (2) Sta. 145, Maldive area, depth 494 m.; 3 males, 1 female.

The specimens agree with the description given by Calman. The ratio of the length of the pterygostomian region to its breadth ranges from 3–4·5 ; the propodi of the 4th and 5th legs are more than twice as long as their respective dactyli, and the exopodites of the uropods reach well beyond the tip of the telson. Two young males from Sta. 115 (these measure 131 and 129 mm.) have the rostrum as long as in the female. The rostrum in one carries ten teeth and in the other eleven teeth. This may be due to the fact that the animals are still young. A similar case has been recorded by Calman in this species and by Bouvier (1908) in *Plesiopenæus edwardisianus*. To the sexual differences described by previous authors I would add that in the females the dactylus and propodus of the 4th pair of legs are as thick as those of the 5th pair, while in the male they are decidedly thicker.



TEXT-FIG. 5.—*a*, *Aristeomorpha* sp. Carapace (tip of rostrum restored), × 1. *b*, *Aristeomorpha foliacea* (Risso). Carapace, × 1·7.

As I pointed out under *Aristeus* (*vide supra*, p. 37), *Aristeus japonicus* Yokoya should in all probability be referred to the genus *Aristeomorpha,* and as *Aristeomorpha foliacea* (Risso) is known to occur in Japanese waters, it is not improbable that *Aristeus japonicus* is a synonym of this species.

DISTRIBUTION.—Mediterranean, East Atlantic and Indo-Pacific regions (400–1300 m.).

Aristeomorpha sp. (Text-fig. 5 *a*.)

OCCURRENCE.—Sta. 115, Zanzibar area, depth 640–658 m. ; 1 female.

Unfortunately in this specimen the tip of the rostrum has been broken and the 4th and 5th legs are missing. In the areolation of the carapace it resembles *A. foliacea*. The following are the measurements in mm. :

Total length.	Rostrum.	Carapace.	Pterygostomian region : Length.	Pterygostomian region : Breadth.	Pterygostomian region : Ratio.
175	27+	52	25	5·5	4·5 : 1

The only observed difference between this specimen and *A. foliacea* lies in the length, armature and peculiar shape of the rostrum. The rostrum in *A. foliaceus* is nearly twice as long as the carapace and reaches beyond the antennular peduncle by a few mm. In *A. foliacea* the rostrum carries seven teeth or more, while in this specimen it carries five teeth only. Again the rostrum shows a peculiar curvature. Diagrams of the carapace of both species are given for comparison in Text-fig. 5 *a*, *b*.

Genus *Hepomadus* Spence Bate.

Alcock, 1901, p. 42 ; Bouvier, 1908, p. 56 ; Burkenroad, 1936, p. 86.

According to both Alcock and Bouvier, the branchial formula of this genus differs from that of *Aristeomorpha* in the absence of a podobranch from the 12th somite and of an epipodite from the 13th somite. But Alcock (1901, p. 42) noticed the presence of a rudimentary epipodite on the 13th somite in a specimen from the Bay of Bengal. Burkenroad confirmed Alcock's observation, with the addition that the rudimentary epipodite is a subrectangular lamella rather than a tiny filament, as stated by Alcock. Burkenroad further observed that a vestigial podobranch is borne by the epipodite on the 12th somite in a juvenile female of *H. tener*, but not in the other available specimens. I am able to confirm Burkenroad's statement of the presence of a rudimentary subrectangular lamella on the 13th somite in a specimen of *H. tener*, and also in the type of *H. glacialis* ; but no podobranch could be seen on the 12th somite. In addition, the presence of small exopodites on the walking legs was noticed. There is also a movable spine on the merus of both the 1st and 2nd legs. This genus comprises three species—*H. tener* Smith, *H. glacialis* Spence Bate and *H. inermis* Spence Bate. The latter species is separated from the others by the absence of the spine on the posterior edge of the 3rd abdominal segment. *H. glacialis* is distinguished from *H. tener* by the possession of spines on the posterior edge of the 4th and 5th abdominal segments and by its characteristic carapace.

Distribution.—*H. inermis*, South Pacific Ocean ; *H. glacialis*, North-west Pacific Ocean, near Yokohama ; and *H. tener*, Atlantic Ocean (east coast of United States, Sargasso Sea) and Indo-Pacific region (Bay of Bengal and East African coast).

Bathymetric range.—Species of the genus are abyssal ; they have never been caught above 1540 m. : *H. inermis* (4665 m.), *H. glacialis* (3429 m.) and *H. tener* (1540–3150 m.).

Hepomadus tener Smith.

Hepomadus tener, Smith, 1884 and 1887 ; Bouvier, 1908 ; Burkenroad, 1936.
? *Hepomadus tener*, Alcock, 1901.

Occurrence.—Sta. 120, Zanzibar area, depth 2930 m. ; 1 female.

From Burkenroad's description of the specimens which he examined it seems that there is great variation in this species. The present specimen, which has been compared with the type of *H. glacialis* and was found to be completely different, exhibits considerable variation from the type in the relative length of the rostrum and the interval between the two anterior rostral teeth, and in the degree of development of the mid-dorsal carina of the carapace. The rostrum (19 mm.) is more than half the length of the carapace (35 mm.), and the interval between the two anterior rostral teeth (3·5 mm.) is one-third of the distance between the last tooth and the tip of the rostrum (10·5 mm.), and about half the distance between the post-rostral and post-orbital teeth (8 mm.). The post-rostral carina is well developed and extends to just in front of the posterior edge of the carapace. The length of the tooth carried by the 3rd abdominal segment is $\frac{6}{11}$ of the distance between the transverse furrow and the posterior margin of the 3rd tergite. The differences between *H. tener* and *H. glacialis* as given by Bouvier (1909, p. 94) do not exist: Bouvier did not see the type of *H. glacialis*, and the specimen, which he (1909) refers to this species, does not belong to it. I have examined the type of the latter, and the following observations clearly indicate that Bouvier's species is different. The post-rostral carina extends to the post-cervical sulcus, then disappears over the cardiac region and appears again. The dorsal side of the carapace is raised and the convexity thus produced is characteristic, as is clearly shown in Spence Bate's figure. The length of the tooth at the posterior end of the 3rd abdominal tergite, as compared with the distance between the transverse furrow and the posterior margin of the 3rd tergite, is $\frac{6}{13}$. The 4th and 5th abdominal tergites are carinate and end in spines. The postero-inferior angle of the 6th abdominal segment is more pronounced than is indicated by Spence Bate's figure. The maxillary palp carries spines on both sides, six spines on its upper side in one row and nine on its lower side in two rows. It is thus evident that Milne-Edwards' and Bouvier's specimen, which they referred to *H. glacialis,* only resembles this latter species in the possession of teeth on the posterior edge of the 4th and 5th abdominal tergites. In the absence of spines from the upper side of the maxillary palp, in the relative shortness of the tooth of the 3rd abdominal segment, and in the dorsal side of the carapace forming a straight line when viewed in profile, Milne-Edwards' and Bouvier's (1909) male specimen differs from *H. glacialis.* If their description of this specimen is perfectly correct, it would seem probable that it represents a new species.

Distribution.—Indo-Pacific area (Bay of Bengal, 2304 m., Zanzibar area, 2930 m.), Atlantic Ocean (East coast of United States, 1541–3365 m., Sargasso Sea, 3150 m.).

Sub-family Solenocerinæ Wood-Mason.

Burkenroad, 1934*a*, p. 63, and 1936, p. 100.

According to Burkenroad this sub-family comprises three genera: *Solenocera, Haliporus* and *Hymenopenæus.* The former is characterized by the flattened antennular flagella being apposable so as to form a respiratory tube. *Haliporus* is separated from *Hymenopenæus* by the possession of podobranchs behind segment VIII. Species of the three genera have been discussed and reviewed by Burkenroad.

Genus *Solenocera* Lucas.

Solenocera hextii Wood-Mason.

Solenocera hextii, Alcock, 1901, p. 20; Illus. Invest. Crust., pt. iv, 1896, pl. 26, fig. 5.

Occurrence.—(1) Sta. 16, Gulf of Aden, depth 186 m.; 1 female.

(2) Sta. 48, South Arabian coast, depth 201–274 m.; 1 female.

The specimen from Sta. 16 is 110 mm. in length and the specimen from Sta. 48 is much smaller and damaged.

Distribution.—Bay of Bengal and Arabian Sea.

Solenocera rathbuni nom. nov. (Text-fig. 6.)

Solenocera lucassii, Rathbun, 1906, p. 904, pl. 20, fig. 9 ; Burkenroad, 1934*a*, p. 68.
[Nec *Solenocera lucassii*, Spence Bate, 1888, p. 277, pl. 42, fig. 4.]

Occurrence.—Sta. 106, Zanzibar area, depth 183–194 m. ; 1 female.

This specimen is 60 mm. long. The rostrum does not reach beyond the eyes. The post-rostral carina, contrary to Rathbun's description, extends beyond the gastric region to just in front of the denticle, which is present on the posterior edge of the carapace; it is fairly distinct for a short distance behind the cervical groove and then becomes weak. The dorsal teeth are seven, of which three are on the carapace. There is no branchiostegal spine, although the carina leading to that part is well developed. From the point where a

Text-fig. 6.—*Solenocera rathbuni* nom. nov. Anterior part of carapace, × 5.

branchiostegal spine would be found a sharp ridge extends to the antennal spine. The antero-inferior angle of the carapace is produced forward in the form of a broad tooth, which cannot be described as a spine. The 3rd–6th abdominal segments are carinated, the carina of the 3rd not extending to the anterior edge of the segment, that of the 6th ending acutely. The telson is longer than the 6th abdominal segment and shorter than the uropods, and carries one pair of fixed spinules. The external maxillipeds reach beyond the antennular peduncle by the dactyl and a quarter of the length of the propodus. The 1st pair of legs is bispinose, carrying a spine on the base and one on the ischium, and reaches the anterior part of the carpus of the 3rd maxillipeds ; the dactyl is longer than the palm. The 2nd pair reaches the middle of the dactylus of the external maxilliped, the basis carrying a spine. The 3rd pair reaches by at least the palm beyond the external maxilliped, the carpus being somewhat expanded at the end.

Distribution.—Hawaiian Islands and Zanzibar area.

Genus *Hymenopenæus* Smith.

Hymenopenæus lucassi (Spence Bate).

Solenocera lucasii, Spence Bate, 1881, p. 185.
Philoncus lucasii, Spence Bate, 1883, p. 277, pl. 42, fig. 4.
Haliporus lucasii, De Man, 1911, p. 43.
? *Haliporus malhænsis*, Borradaile, 1910, p. 258, pl. 16, fig. 2.
[Nec *Solenocera lucasii*, Rathbun, 1906, p. 904, pl. 20, fig. 9.]

Occurrence.—Sta. 153, Maldive area, depth 256–293 m. ; 1 female.

This specimen is 70 mm. long and is completely identical with the type-specimen, with which it has been compared. Borradaile's description of *Haliporus malhœnsis* is not sufficiently detailed to enable one to determine the identity of the two species, but his figure suggests that they are identical. Unfortunately the type of Borradaile's species no longer exists, so a comparison of both types could not be made.

Distribution.—Near Tanah Djampeah (120–400 m.), Halmaheira Sea (411 m.) (De Man); off the Kei Islands, South of Papua (Spence Bate); Saya de Malha (265 m.) (Borradaile).

Hymenopenœus propinquus (De Man).

Haliporus propinquus, De Man, 1911, p. 33, pl. 3, fig. 9.
Hymenopenœus propinquus, Burkenroad, 1936, p. 104.

Occurrence.—(1) Sta. 108, Zanzibar area, depth 786 m.; 1 male, 1 female.
(2) Sta. 109, Zanzibar area, depth 640 m.; 8 males, 2 females.
(3) Sta. 115, Zanzibar area, depth 640–658 m.; 3 females.
(4) Sta. 145, Maldive area, depth 510 m.; 36 males, 74 females.
(5) Sta. 193, Gulf of Aden, depth 1061–1080 m.; 4 males, 5 females.

The examples are not as large as those taken by the "Siboga". The largest range from 70–80 mm. long. The specimens taken at Sta. 115, Sta. 109 and Sta. 193 differ in some respects from those taken at Sta. 145; those taken at Sta. 108 are rather damaged. The specimens from Sta. 109, 115 and 193 all have the rostrum obliquely ascending and straight on both edges, as described by De Man, while those from Sta. 145 have the rostrum decidedly convex (in few cases very slightly). Again the 1st and 2nd legs in the specimens from the Zanzibar area agree with De Man's description, while in those from the Gulf of Aden they fail to reach as far as is stated by De Man. However, in the 3rd maxilliped and in the petasma the reverse is the case. The specimens from Sta. 145 in the Maldive area agree with De Man's descriptions, the 3rd maxilliped reaching beyond the scaphocerite by the dactylus only, while in those from the Zanzibar area the 3rd maxilliped reaches beyond the scaphocerite by the dactylus and from $\frac{1}{4}$–$\frac{1}{2}$ the propodus. Again the petasma of the male specimens from the Gulf of Aden agrees with De Man's description in having the anterior lobule much longer than the posterior one, while in the Zanzibar specimens the posterior lobule is very slightly shorter than the anterior one.

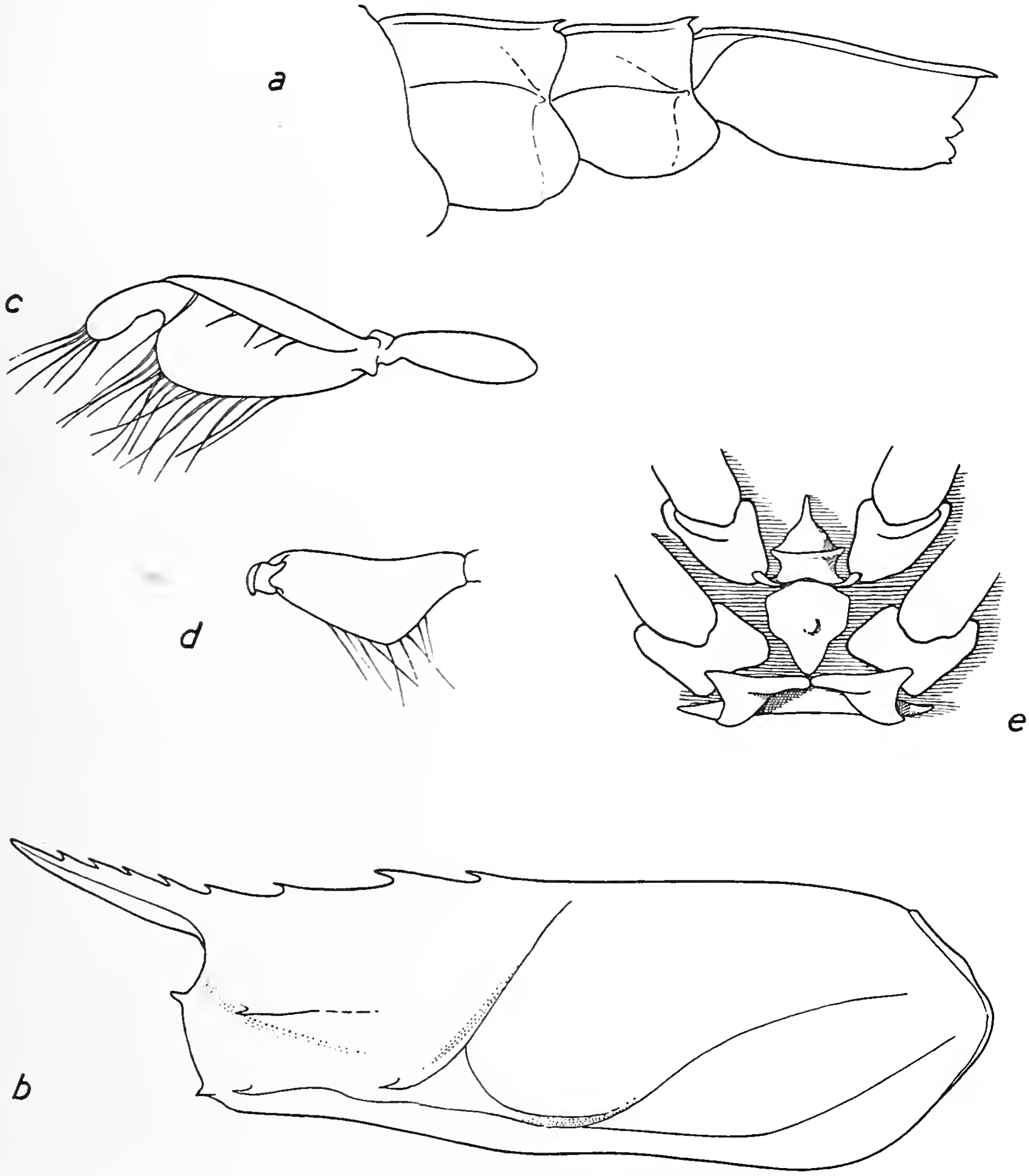
From De Man's description all the specimens differ in that the carina on the 1st abdominal segment is invariably absent.

Distribution.—Ceram Sea (835 m.), Bali Sea (538 m.), De Man.

Hymenopenœus sewelli sp. nov. (Text-fig. 7 *a–e.*)

Occurrence.—Sta. 156, Maldive area, depth 1828 m.; 1 female.

This female specimen is 65 mm. long. The integument is sub-membranous and leathery. The rostrum is obliquely ascending, but not straight, and carries 6 teeth. It extends beyond the middle of the 2nd segment of the antennular peduncle. The post-rostral carina is well developed and extends not quite to the posterior end of the carapace, the part anterior to the cervical groove is better developed than the part posterior to it, and is as high as the rostrum and carries two teeth. The carapace carries laterally five teeth, an antennal spine, a pterygostomian spine at the anterior edge of the carapace, a post-orbital spine at a lower level than the antennal, a branchiostegal spine behind and at the same level as the pterygostomian, and a hepatic spine at the anterior end of the cervical groove. All the spines, except the antennal one, are prolonged backwards in the form of a carina. The posterior carina of the branchiostegal spine is long, and behind it two carinæ run backwards along the branchial region; the upper one ends at the posterior



TEXT-FIG. 7.—*Hymenopenæus sewelli* n. sp. *a*, Posterior part of abdomen, × 4. *b*, ♀ carapace, × 4. *c*, Epipodite on 1st leg. *d*, Epipodite on 4th leg. *e*, Thelycum, × 11.

margin of the carapace, and the lower one runs downwards and backwards to join the submarginal carina of the carapace.

The 4th to 6th abdominal segments are sharply carinated, the carinæ being very high and ending in acute teeth (Text-fig. 7 *a*). The 5th segment carries a longitudinal carina laterally and the 4th segment is grooved posteriorly. The 6th abdominal segment is less than twice as long as the 5th. The telson is unfortunately broken, but sufficient remains to show that it must have been longer than the 6th segment.

The eyes are black and not much wider than the peduncle. They extend to the middle of the basal segment of the antennular peduncle. The basal segment of the antennular peduncle bears at its antero-external angle a well-developed spine. The 2nd segment is more than twice as long as the 3rd.

The 1st pair of legs reaches the middle of the carpus of the 3rd maxilliped. The fingers are almost $1\frac{1}{2}$ times as long as the palm. The 2nd pair of legs reach beyond the end of the carpus of the 3rd maxilliped, and the fingers are just longer than the palm. The 3rd pair of legs is missing. The dactyls and propodus of the 4th and 5th pairs are also missing, but the carpus of the 5th pair reaches the end of the antennular peduncle. Exopodites are present on all the legs, but are very small. Epipodites are present on all the legs except the last. The basal part of the epipodite is short and broad, not more slender than the terminal broad lamina, and the latter is not furcate but has one side more pronounced than the other; the lamina is less broad on the posterior legs than on the anterior ones (Text-fig. 7 *c*, *d*).

Thelycum (Text-fig. 7 *e*)—The coxæ of the 3rd pair of legs are produced inward as large tubercles, on which the oviducts open, and are covered with stiff hair. Behind these on either side is an elongate tongue-like sternal structure. Between the 4th pair of legs is a structure which is divided into an anterior part, and a posterior part which is deeply notched posteriorly. The posterior part is more or less vertical. Between the 5th pair of legs is a more or less conical structure covered with hair.

The specimen appears to represent a new species of *Hymenopenæus* belonging to Section 1 of Group IV of Burkenroad. This section is characterized by the possession of a branchiostegal and pterygostomian spine on the carapace. This species is more related to *H. nereus* (Faxon) than to *H. doris* (Faxon) or *H. lævis* (Bate).

Before stating the differences between this species and *H. nereus* Faxon and related species, I would note that Faxon's description of the 3rd abdominal segment is not correct. Faxon (1895, p. 189) writes, "the 3rd to 6th abdominal segments are carinated". Mr. Fenner A. Chase, jun., of the Museum of Comparative Zoology, Harvard, who had kindly examined four specimens of Faxon's material, informs me that "the 3rd abdominal segment is not carinated in any of the specimens; the 4th and 5th abdominal segments show no trace of a posterior spine; on the other hand, they are notched for the reception of the succeeding segments; the structure on the sternum of the 5th legs is not triangular, but just as shown in Faxon's figure". The present species differs from *H. nereus* by the following:

(1) The shape of the rostrum.

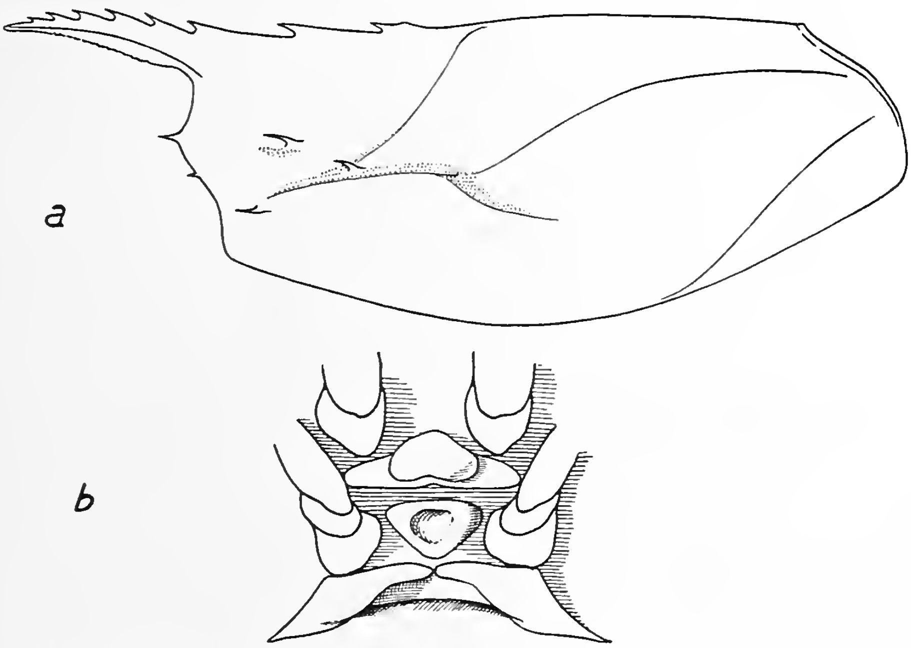
(2) The carina of the 4th and 5th abdominal segments, which in this species end in acute teeth, while in *H. nereus* and related species they are notched posteriorly.

(3) The shape of the thelycum.

Hymenopenæus fattahi, sp. nov. (Text-fig. 8 *a*, *b*.)

Occurrence.—Sta. 54, South Arabian coast, depth 1046 m.; 42 males, 19 females.

These examples represent a new species of *Hymenopenæus* belonging to Section 2 of Burkenroad's Group IV. This section is characterized by the possession of a branchiostegal spine, but not of a pterygostomian one, and by having the 4th and 5th pairs of legs very long, reaching far beyond those of the 3rd pair. The length of the specimens varies from 40–50 mm. The integument is semi-membranous and glabrous. The rostrum is obliquely ascending in both sexes. In some specimens it is nearly straight, but in the majority it is slightly arched. The lower margin is fringed with long hairs. It reaches the end of the 1st antennular peduncle and carries six to seven teeth, besides the two epigastric ones. The post-rostral carina runs to the middle of the carapace, a few mm. beyond the level of the cervical groove. The carapace is armed with four spines, an antennal, a post-orbital, a hepatic and a branchiostegal spine behind and above the antero-inferior angle of the carapace. All the spines are comparatively small ; the antennal is very small and in some specimens is almost absent. The post-orbital spine is placed on the same level as the antennal one and the hepatic at a slightly lower level. The anterior edge of the carapace below the antennal spine does not round into the lower edge, as in other



TEXT-FIG. 8.—*Hymenopenæus fattahi* n. sp. *a*, Carapace, × 6. *b*, Thelycum.

species, but there is a distinct angle at the antero-inferior corner of the carapace, the anterior edge of the carapace being straight. On the branchiohepatic region there is a well-developed L-shaped groove with the posterior limb almost parallel to the dorsal edge of the carapace. The anterior part of the branchiostegal region is sharply defined, and bulges at a higher level than the rest of the carapace. The 1st–3rd abdominal segments are not carinated ; the 4th–6th segments are carinated, the 6th alone ending in a spine. The carina of the 4th and 5th segments are cut posteriorly for the reception of the succeeding segments.

The telson is longer than the 6th abdominal segment and carries a pair of small fixed spinules. It is broadly concave throughout the whole length. The eyes are wider than the peduncles and not completely black, having a brownish tinge. The antennular peduncle does not reach the end of the scaphocerite, the distance between the end of the peduncle and that of the scaphocerite being almost equal to the terminal segment. The antennal peduncle reaches beyond the end of the 1st segment of the antennular peduncle. The external maxillipeds reach beyond the scaphocerite by less than the dactylus. The

1st pair of legs reaches the end of the 1st antennular segment and carries no spines; the setiferous organ is well developed; the finger is $1\frac{1}{2}$ times as long as the palm, measured along the middle line, and the carpus is a little shorter than the merus. The 2nd pair of legs reaches beyond the end of the 2nd antennular segment; the finger is $1\frac{1}{2}$ times as long as the palm and the carpus is longer than the merus. The dactylus and propodus of the 4th and 5th legs are missing in all the specimens, but the carpi reach almost to the end of the antennular peduncle. There are no exopodites on the legs, but epipodites are present on all the legs except the last. The epipodites (except that of the 4th leg) are well developed, the stalk is very long, the terminal lamina is well furcated. The epipodite on the 4th leg is a mere filament without furcate lamina. Each half of the petasma is divided into two unequal lobules, the anterior being longer and its obtuse tip nicked. The posterior lobe is more or less triangular. The edge of the anterior lobe is beset with stiff microscopic spinules. There is a round tooth on the sternum of the 1st abdominal segment in the male.

The thelycum is represented in Text-fig. 8 *b*. The two tubercles on which the oviducts open are longer than broad and are covered with hair: behind these is a pair of small sternal structures. Between the basis of the 4th legs there is a plate, rounded anteriorly with obtuse upper edge and bounded posteriorly by two processes from the bases of the 4th legs. This plate is covered with hair.

In spite of the great number of specimens obtained, there is not a single specimen which is in good condition: the softness of the tissues of the animals and the change of pressure (the animals having been taken at a depth of 1046 m.) may be responsible for this.

This species is easily distinguished from the others belonging to Group IV, Section 2 of Burkenroad by the semi-membranous integument and soft tissues and by the presence of the L-shaped groove on the branchial region.

Sub-family Penæinæ.

Genus *Penæus* Fabricius.

Penæus indicus Edwards.

Penæus indicus, Alcock, 1906, p. 62, pl. 1, figs. 3, 3*a*.

Occurrence.—Sta. 37, Gulf of Aden, depth 18–22 m.; 1 male.

The specimen is 165 mm. long. The rostral formula is 8 : 4. The post-rostral carina extends backwards to about 5 mm. in front of the posterior edge of the carapace and carries a very fine groove which widens in two regions, one 4 mm. and the other 1·5 mm. in length. De Man (1911, p. 103) has found in the variety *longirostris* that the post-rostral carina, though not grooved, shows usually two or three shallow pits.

Distribution.—Indo-Pacific region.

Penæus marginatus Randall.

Penæus marginatus, Rathbun, 1906, p. 55, pl. 19, fig. 2.
? *Penæus canaliculatus*, De Man, 1888, p. 565.

Occurrence.—Station unknown; 1 female.

The specimen is 180 mm. long. The post-ocular crest turns upon itself at the posterior end, and forms a loop as found in the Indo-Pacific species of Division 2 of

Burkenroad. The 1st leg is bispinose and the post-rostral carina is not grooved. The telson carries 3 pairs of spinules. In 1888 De Man (*loc. cit.*) described two female specimens which were identified by him as *P. canaliculatus*. In these the post-rostral carina is not grooved and the 1st legs are bispinose. In 1911, p. 107, under *P. canaliculatus*, he refers to these two females as individual varieties of the latter species, but it is quite probable that they actually belong to *P. marginatus*.

DISTRIBUTION.—Indo-Pacific region.

Genus *Trachypenæus* Alcock.

Burkenroad, 1934*a*, p. 94, and *b*, p. 49.

Trachypenæus curvirostris (Stimpson).

Penæus anchoralis, Spence Bate, 1888, p. 258, pl. xxxv, fig. 1, part (only males).
Trachypenæus asper, Alcock, 1906, p. 43, pl. 9, figs. 28, 28*a* and *b*.
Trachypenæus anchoralis, De Man, 1911, p. 88, pl. 8, fig. 28.
Trachypenæus anchoralis, Schmitt, 1926, p. 353, pl. 63, figs. 2, 3.
For further synonymy see Schmitt.

OCCURRENCE.—Sta. M.B. I, Red Sea, depth 26 m.: 1 female.

The specimen is 55 mm. long. The rostrum is straight, and carries 10 teeth in addition to the epigastric one. The post-rostral carina is sharp and well-developed. The antero-inferior angle of the carapace is slightly dentiform. The thelycum exactly resembles the figure given by Schmidt. The longitudinal suture of the carapace in front of the hepatic spine is faint and is only seen when carefully looked for. There is no spine on the basis of the 3rd maxilliped and the ischium of the 1st leg carries no spine. There is an epipodite on the 1st and 2nd legs, as well as on the 3rd.

Among the characters used by Burkenroad, for separating members of Section 2 from Section 1, in Division I, is the presence of a spine on the ischium of the 1st leg. No great importance should be attached to this character, as the presence or absence of a spine is subject to variation, at least in this species. As mentioned above, there is no spine on the ischium in the present specimen. Alcock (in *T. asper*) and De Man (in *T. anchoralis*) mention the presence of a spine on the basis but not on the ischium. However, the spine on the ischium is present in two male specimens from the "Challenger" Collection, and is missing in the other two males.

DISTRIBUTION.—Indo-Pacific region.

Genus *Funchalia* Johnson.

Burkenroad, 1936, p. 126.

Sub-genus *Funchalia*.

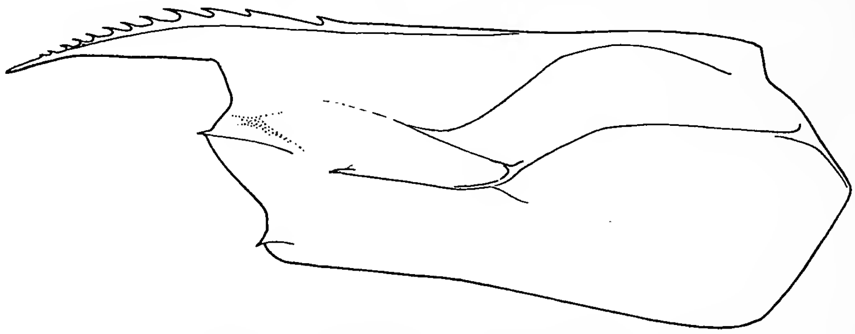
Funchalia (*Funchalia*) *woodwardi* Johnson (Text-fig. 9).

Funchalia woodwardi, Calman, 1925, p. 10, pl. 2, fig. 5, pl. 3, figs. 6–8.
Funchalia woodwardi, Burkenroad, 1936, p. 126.

OCCURRENCE.—Sta. 96, Central part of Arabian Sea, depth 10 m.; 1 male, 2 other very small specimens.

The largest specimen (male) is 50 mm. long; the length of the carapace from the base of the orbit to the hind dorsal edge is 13 mm. The two very small specimens are

25–27 mm. long. The large specimen agrees with Calman's description and differs from Bouvier's in the following: (1) The mandible; (2) the possession of only two branchiæ (pleurobranch and arthrobranch) besides the podobranch on the somite of the 2nd maxilliped; (3) the possession of a row of spinules on the telson instead of three pairs. It differs, however, from Calman's figure in two respects: (i) In the holotype and in the specimen from South Africa (as shown by Calman's figure) the pterygostomian spine is placed at the antero-inferior angle of the carapace, while in this specimen it is placed at a higher level; (ii) the rostrum in the holotype is broken, but in Calman's specimen from South Africa, which I have examined, it is broad at the base and its lower margin rounds into the anterior edge of the carapace, while in this specimen the junction of the lower



TEXT-FIG. 9.—*Funchalia* (*Funchalia*) *woodwardi* Johnson. Carapace, × 6·7.

margin and the carapace is angular. These differences may be due to this specimen not having assumed fully adult characters. I would note here that Calman's figure omits—(1) a ridge on the carapace dorsal to the one carrying the hepatic spine and with which it is connected; (2) a lateral groove on the 4th abdominal segment. Both structures were found to be present in the type-specimen and in the specimen from South Africa, both of which I was able to examine in the British Museum. The two small specimens seem to be a post-larval stage of *Funchalia*. In these the body is not pubescent, the eyes are not wider than the eye stalks, and the prosartema does not reach beyond the cornea of the eye.

DISTRIBUTION.—Eastern North Atlantic and South-eastern Atlantic regions (Burkenroad); Indo-Pacific region (Balss).

Sub-genus *Pelagopenæus* Burkenroad.

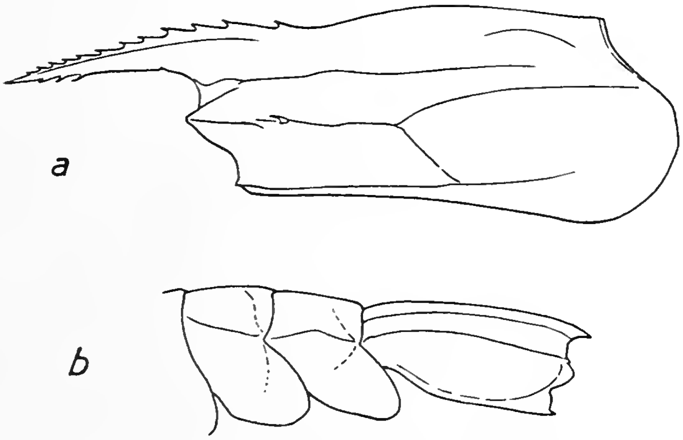
Burkenroad, 1936, p. 77.

Funchalia (*Pelagopenæus*) *balboæ* (Faxon). (Text-figs. 10 *a*, *b*; 11 *a–g*.)

Penæus balboæ, Faxon, 1895, p. 181; Schmitt, 1935, p. 20.
Penæus meridionalis, Lenz and Strunk, 1914, p. 298.
Funchalia (*Pelagopenæus*) *balboæ*, Burkenroad, 1934*a*, p. 76; 1936, p. 136.
Funchalia (*Pelagopenæus*) *meridionalis*, Burkenroad, 1934*a*, p. 77.

OCCURRENCE.—Sta. 96, Central part of the Arabian Sea, depth 10 m.; 2 specimens.

Integument soft but not membranous, and glabrous. The rostrum extends a little beyond the end of the 2nd segment of the antennular peduncle, and carries a carina on the lateral side. In the large specimen the rostral formula is 12 : 3 and in the small specimen 13 : 3. Besides the three teeth on the ventral edge of the rostrum in the large specimen, there is a rudiment of another one. Of the dorsal teeth three lie on the carapace (Text-fig. 10 *a*). The rostrum is more than half the length of the carapace : the latter measured 12 mm. along the lateral wall from the antennal spine to the posterior edge exactly along the central ridge which carries the hepatic spine ; the rostrum measured 9·5 mm. The post-rostral carina is as high as the rostrum, and extends to a few mm. in front of the posterior edge of the carapace. There is a pterygostomian spine at the anterior edge of the carapace. On the lateral side of the carapace there are four ridges, the most prominent of which carries the hepatic spine and extends along the carapace from the antennal spine to the posterior edge : this ridge is not continuous, but is interrupted just in front of the hepatic spine. The ridge below this extends backwards from the pterygostomian spine, but does not reach the posterior edge of the carapace. These two ridges are connected by a transverse ridge. The other two ridges are dorsal to that carrying the hepatic spine ; the ventral one is shorter than the one last mentioned and

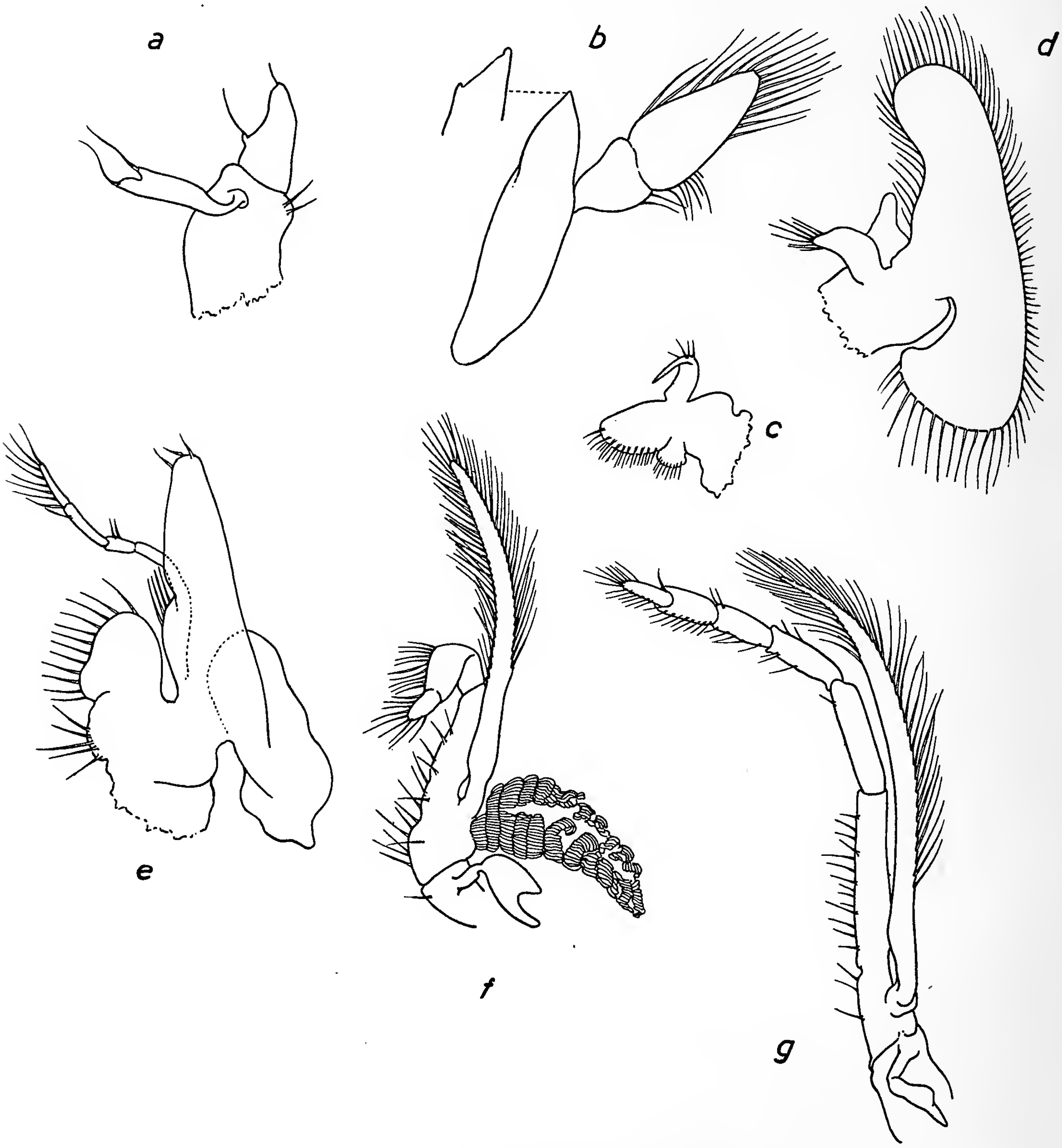


TEXT-FIG. 10.—*Funchalia (Pelagopenæus) balboæ* (Faxon). *a*, Carapace, × 4·7. *b*, Three posterior abdominal segments, × 4·7.

does not reach either edge of the carapace. The dorsalmost ridge is short and is confined to the posterior part of the carapace but does not reach the posterior edge. The 4th–6th abdominal segments each carries a high carina, the last ending in a spine. The pleura of the 4th and 5th segments are prolonged backwards (Text-fig. 10 *b*). The 4th–6th abdominal segments each carries laterally a well-developed ridge, that on the 4th segment being oblique. The 6th abdominal segment is a little longer than the 4th and 5th together. The telson is symmetrical, slightly shorter than the 6th segment and very broadly grooved, with the upper edges of the grooves very sharp. I am unable to find more than three pairs of very minute spinules on the posterior end of the telson.

The eyes are sub-spherical and not quite black, having a brown tinge ; they are twice as wide as the stalk in the large specimen, while in the small specimen they are not much wider than the stalk : this is probably due to age. The prosartema is short and does not reach the end of the eyes. The outer wall of the basal segment of the antennular peduncle is raised. The 3rd segment is more than half as long as the 2nd. The antennular flagella are long, thickened at the base, the outer being shorter than the inner and the latter is less than twice as long as the antennular peduncle. The mandibular crown is prolonged inward, but is not long enough to be described as of a stylet form

(Text-fig. 11 *b*). The proximal endite of the 2nd maxilla is missing, as it is in the sub-genus *Funchalia*. The 3rd maxillipeds reach the base of the scaphocerite. The legs are short; the 2nd are a little shorter than the external maxillipeds; the 3rd reach almost the middle



TEXT-FIG. 11.—*Funchalia* (*Pelagopenæus*) *balboæ* (Faxon). *a*, Epipodite on 3rd leg. *b*, Mandible. *c*, 1st maxilla. *d*, 2nd maxilla. *e–g*, Maxillipeds.

of the eye; the 4th legs are a little shorter than the 3rd, and the 5th are shorter than the 4th. I am unable to find any exopodites on any of the legs. The epipodites are missing from the 4th and 5th legs, and the broad lamina of the epipodites on the other legs are furcate in the usual way.

The edges of the fingers are sharp and the movable fingers carry two teeth. The setiferous organ is present on the 1st leg.

The smaller specimen does not show any trace of sexual organs, the larger one carries a small lamina on the inner edge of the 1st abdominal limb, and the sternum of both specimens of the 1st abdominal segment carries a well-developed tubercle.

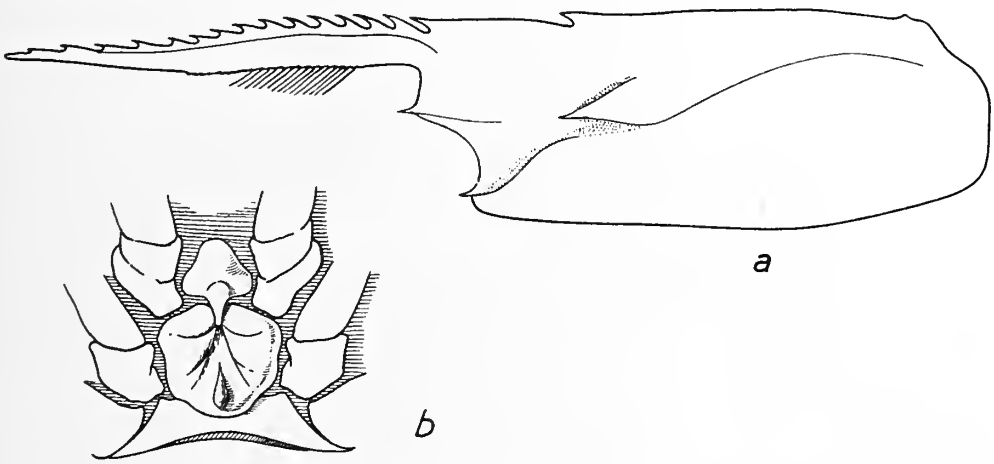
DISTRIBUTION.—American Pacific region, North Atlantic region.

Penæopsis rectacutus (Spence Bate). (Text-fig. 12 *a*, *b*.)

Parapenæus rectacutus, Alcock, 1906, p. 33, pl. vi, figs. 19, 19*a* and *b*; Illus. Invest. Crust., pt. ix, 1901, pl. 49, fig. 5.
? *Parapenæus rectacutus*, De Man, 1911, p. 82.
Parapenæus rectacutus, Balss, 1925, p. 228.
Penæopsis rectacutus, Burkenroad, 1934*b*, p. 13.

OCCURRENCE.—Sta. 16, Gulf of Aden, depth 186 m.; 40 females, 20 males.

The largest specimen is 105 mm. All the specimens agree with the description and figures given by Alcock, except that the rostrum is not exactly straight; there is a slight curvature in the middle of its length (Text-fig. 12 *a*). In the females the rostrum reaches the end of the antennular peduncle. The number of the rostral teeth varies from 10–14.



TEXT-FIG. 12.—*Penæopsis rectacutus* (Bate). *a*, Carapace, × 3. *b*, Thelycum, × 5·3.

The ridge defining the anterior part of the cervical groove agrees exactly with Alcock's figure. The pterygostomian spine is placed higher than the antero-inferior angle of the carapace, which is almost square-shaped. The hepatic spine is almost at the same level as the antennal. In the majority of the specimens the telson carries three pairs of movable spinules, besides the fixed pair; in one female it carries only one pair, and in two males and two females it carries two pairs. The 1st pair of legs is bispinose, and the 2nd pair is devoid of spinules in all the specimens. From the above and from the descriptions of Alcock and Balss, it appears that either two or three pairs of mobile spines may be present on the telson and that the 2nd leg may carry a spine or not; these differences must therefore be attributed to intra-specific and not inter-specific variation. The thelycum agrees with the figure given by Alcock (1906, fig. 19 *b*—*vide* Text-fig. 12 *b*).

It would appear doubtful whether the specimens obtained by the "Siboga" and attributed by De Man to this species really belong to it, for De Man states that each lobe of the petasma at its distal end is armed with a sharp spine ; such spines are not found in the type of this species, but are present in the type of *P. serratus* (see below under *P. serratus*). Unfortunately, De Man does not say anything about the shape of the thelycum.

Distribution.—Indo-Pacific region.

Penæopsis serratus (Spence Bate). (Text-fig. 13 *a–d*.)

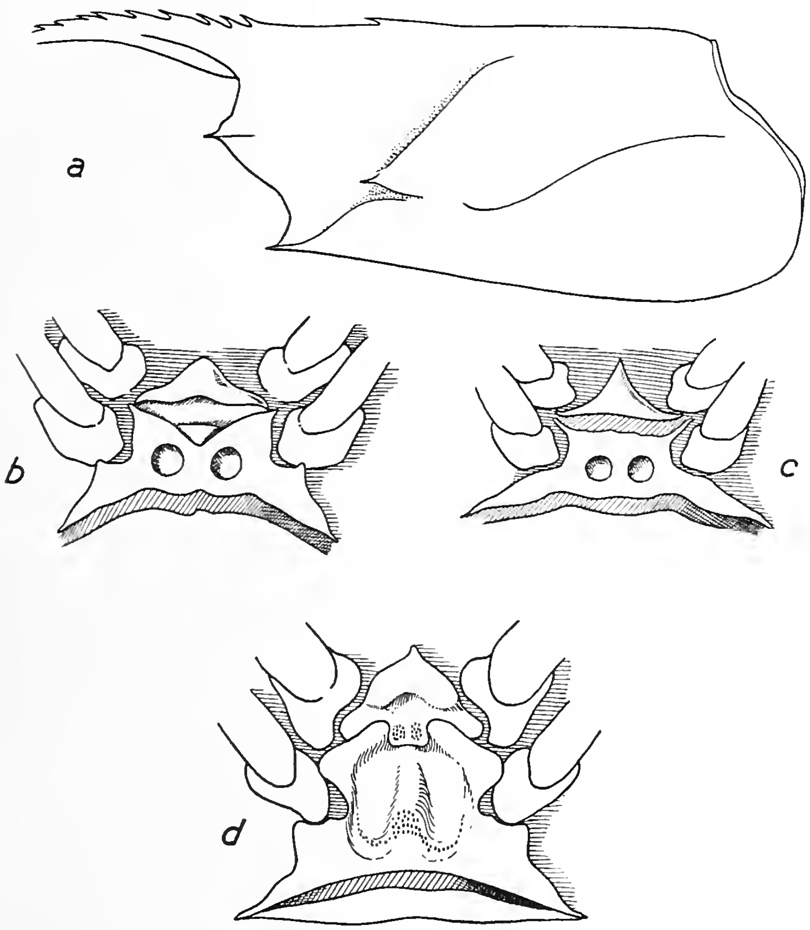
Penæus serratus, Spence Bate, 1888, p. 268, pl. xxxvii, fig. 1.
? Penæopsis challengeri, De Man, 1911, p. 76.
Penæopsis serratus, Balss, 1925, p. 229, fig. 4 ; Burkenroad, 1934*b*, p. 13.

Occurrence.—(1) Sta. 105, Zanzibar area, depth 280 m. ; 17 females, 11 males.
(2) Sta. 107, Zanzibar area, depth 428–457 m. ; 1 female.
(3) Sta. 110, Zanzibar area, depth 347–384 m. ; 3 females.

The largest specimen is 115 mm. The rostrum is arched, carries 9–10 teeth, and reaches the end of the 1st segment of the antennular peduncle. The hepatic spine is placed at a lower level than the antennal and the anterior part of the cervical groove is oblique. The pterygostomian spine is placed just above the antero-inferior angle of the carapace, which is very rounded (compare Text-fig. 13 *a* with 12 *a* of *P. rectacutus*). The thelycum agrees with the figure given by Balss (1925). Although the thelycum of *P. rectacutus* and *P. serratus* are built on the same plan, yet on comparing specimens of the two species the difference is seen to be very marked (compare Text-figs. 13 *b* and 12 *d*).

During a visit to the Berlin Museum I examined the material of the German Deep-Sea Expedition that was identified by Balss as *P. serratus*, and found that the specimens are exactly similar in every detail to those taken by the John Murray Expedition. Whether De Man's *P. challengeri* is the same as that of Balss is not known ; Balss himself is uncertain. Spence Bate's species, however, seems to be different. Spence Bate's figure of the thelycum (1888, pl. 37, fig. 1‴) is completely different from the thelycum of both the large female described above and those of Balss. On examining the specimens from which Spence Bate's figure was drawn, it was seen that his figure of the thelycum is not very correct, but it is, at any rate, very different from the others. Again, the petasma of Spence Bate's specimen is different from the petasma of the males examined by Balss, for, as is shown by his figure and confirmed by my examination of the specimen, it is furnished distally on each side with an anteriorly-directed sharp slender process ; whereas in Balss's males the petasma is rounded anteriorly. Owing to these marked differences in the thelycum and petasma, it is with considerable reluctance that I have followed Balss and referred the specimen to *P. serratus*. If more material should be discovered later on in which the thelycum and petasma agree with Spence Bate's type of *P. serratus*, a new species will have to be established for Balss's specimen and for the specimen referred to above. It is not improbable that the male specimens referred by De Man to *P. rectacutus* are identical with Spence Bate's species. Burkenroad (1934, p. 13) states that no clear diagnostic distinction between *P. rectacutus* and *P. serratus* has ever been established. With regard to this I am of the opinion that there should be no question of the validity of *P. rectacutus* ; this species is easily separated by the shape of the rostrum, the shape of the anterior part of the cervical groove, the position of the hepatic spine in relation to the antennal one, the position of the pterygostomian spine and the shape of the thelycum: other differences, viz., the number of spines on the telson and the spinosity of the 2nd leg, must be regarded as intra-specific variations similar to those that, as I have pointed out, are found in *P. rectacutus*.

The specimens from Sta. 105 are young and the largest one of them is only 60 mm. in length. They are referred to this species on account of the position of the hepatic



TEXT-FIG. 13.—*Penæopsis serratus* (Bate). *a*, Carapace, × 2·7. *b*, *c*, Central part of thelycum in two young females, × 8. *d*, Thelycum, × 5·3.

spine and the shape of the ridge defining the anterior part of the cervical groove. The thelycum in these smaller females is different from that in the adult. In Text-fig. 13 *b–d* I have given the outlines of three thelyca, showing different stages of development.

DISTRIBUTION.—Indo-Pacific region.

Penæopsis (*Metapenæopsis*) *coniger* (Wood-Mason).

Metapenæus coniger, Alcock, 1906, p. 25, pl. iv, figs. 12, 12*a* and *b*; Illus. Invest. Crust., pt. ix, 1901, pl. l, figs. 2, 2*a* and *b*.
See Calman, 1923, p. 536.

OCCURRENCE.—(1) Sta. 16, Gulf of Aden, depth 186 m.; 8 males.
(2) Sta. 70, Gulf of Oman, depth 196 m.; 1 female, 1 male.
(3) Sta. 71, Gulf of Oman, depth 106 m.; 8 males.

(4) Sta. 75, Gulf of Oman, depth 201 m.; 1 female.

(5) Sta. 89, Northern area of Arabian Sea, depth 135–183 m.; 1 male.

(6) Sta. 194, Gulf of Aden, depth 220 m.; 13 females, 5 males.

While all the females can safely be referred to this species, it is with less certainty that the males are referred to it. The females of this species are easily distinguished from the females of *P. philipii* (Spence Bate) by the shape of the thelycum. Calman (1923, p. 539) writes: "I am inclined for the present to leave *P. coniger* apart as possibly a separate species, although I am unable to point to any distinctive characters except those of the thelycum." Alcock (1901) distinguished *P. coniger* from *P. philipii* by the relative length of petasma, which was said to be about one-third as long as the carapace in *P. coniger* and at least half as long in *P. philipii*. With regard to this distinction Calman writes: "In the specimens I have examined, it is at most much less marked than is implied in the earlier description." The examination of the abundant material of *P. philipii* obtained by the John Murray Expedition showed that, although the measurements as given by Alcock were not very exact, yet there is a noticeable difference between the relative measurements of the petasma in both species. In *P. coniger* it is either half as long as the carapace or less. In *P. philipii* it is invariably more than half as long as the carapace, the petasma being measured from the anterior part to the extreme end of the posterior prolongation and the carapace measured along the mid-dorsal line. The males from Stas. 70 and 71 have the petasma half as long as the carapace, while the males from Stas. 16, 89 and 194 have the petasma less than half the carapace. Exopodites are present on all the walking legs.

Distribution.—Indo-Pacific region.

Penæopsis (*Metapenæus*) *philipii* (Spence Bate).

Calman, 1923, p. 536, figs. 1, 2.

Occurrence.—(1) Sta. 105, Zanzibar area, depth 238–293 m.; 2 females.

(2) Sta. 106, Zanzibar area, depth 183–894 m.; 95 females, 142 males.

All the normal males have the petasma more than half as long as the carapace. Eleven males are parasitized with a Bopyrid parasite; in these the petasma is much reduced, and the inner antennular flagellum lacks the concavity and the spine at the base, and thus resembles that of the female. Exopodites are present on all the legs. The thelycum exhibits wide variations, as has already been shown by Calman.

Distribution.—Indo-Pacific region.

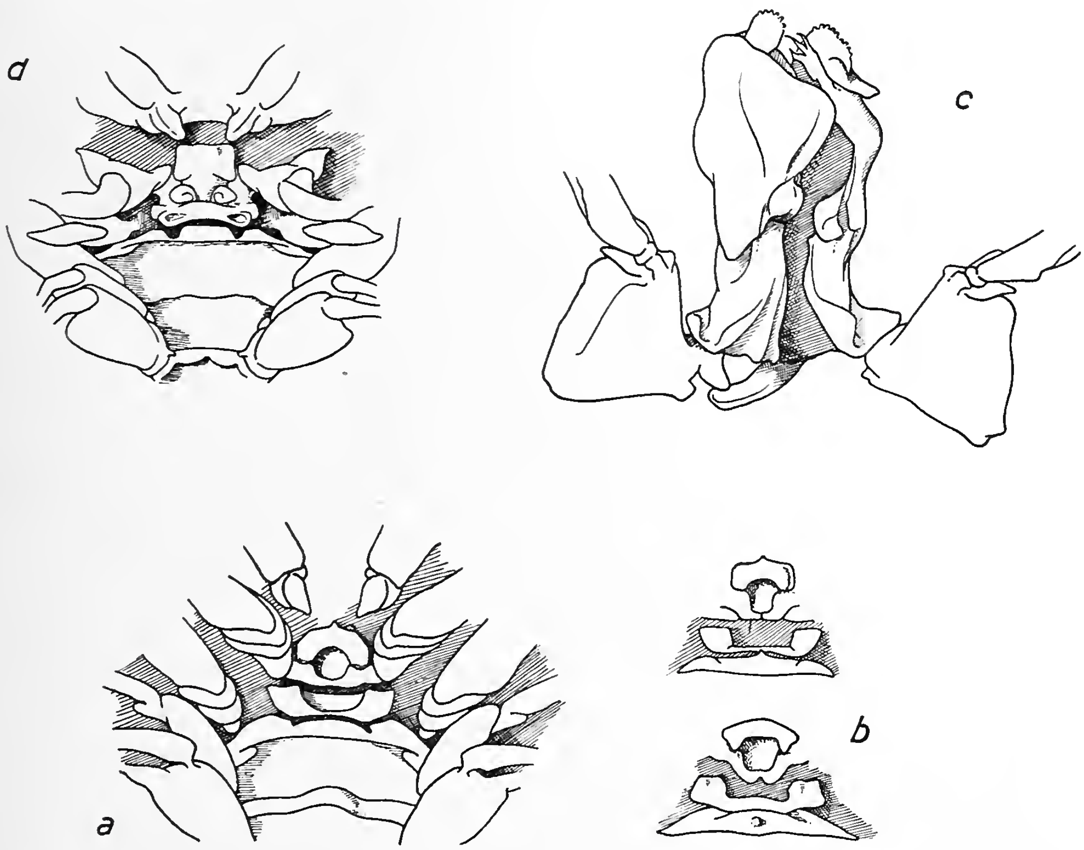
Penæopsis (*Metapenæus*) *vaillanti* Nobili. (Text-fig. 14 *a–c*.)

Penæopsis vaillanti Nobili, 1906, p. 18, pl. 1, fig. 4; Tattersall, 1921, p. 366, pl. 27, fig. 12.

Occurrence.—(1) Sta. 27, Gulf of Aden, depth 37–91 m.; 1 female, 3 males.

(2) Sta. 80, South Arabian coast, depth 16–22 m.; 7 females, 6 males.

In all the specimens the rostrum is straight and carries 6–7 teeth besides the epigastric one. The largest specimen taken (a female from Sta. 27) is 60 mm. in length. I have in front of me two large specimens (length 75 mm.) from the Red Sea. In these the lower edge of the rostrum is not straight, but is slightly convex. The rostrum reaches the middle of the 2nd segment of the antennular peduncle in the large specimen and in the two specimens from the Red Sea ; in the smaller specimens it does not reach beyond the end of the 1st segment. The post-rostral carina does not extend beyond the gastric region. The antero-inferior angle of the carapace is produced as an acute tooth. The eyes are much wider than the eye-stalks. The 2nd abdominal segment carries a short carina in the middle part ; the 3rd to 6th segments are carinate, the carina of the 3rd being sulcate and that of the 6th ending acutely. The latter segment is about $1\frac{1}{2}$ times as long as the 5th, and is shorter than the telson. which is just shorter than the inner rami of the uropods. The telson carries one pair of immovable spines and three pairs of movable



TEXT-FIG. 14.—*Penæopsis vaillanti* Nobili. *a*, Thelycum, × 6·7. *b*, Central part of thelycum in two smaller specimens. *c*, Petasma, × 13·3. *Penæopsis faouzii* n. sp. *d*, Thelycum, × 6·7.

ones. Exopodites are found on all the legs and epipodites on the first three. The 1st pair of legs carries a spine on both the basis and the ischium and the 2nd pair on the basis. In small specimens (length 35 mm.) the 3rd pair of maxillipeds reaches the end of the scaphocerite and the 3rd pair of legs is shorter than the external maxillipeds, and reaches beyond the antennular peduncle. In the large specimen from Sta. 27 and in the two specimens from the Red Sea, however, the legs are shorter than in the young, the external maxillipeds reaching only to the end of the 2nd segment of the peduncle, and the 3rd pair of legs to the end of the propodus of the external maxillipeds. The thelycum (Text-fig. 14 *a*, *b*) is composed of two plates between the 4th pair of legs and two between the 5th pair. The hindmost of these is cut into three lobes and the one in front of it is deeply concave anteriorly. The most anterior plate is oblique, neither vertical nor horizontal; the one behind it is vertical, composed of two pieces, and is semicircular. The two anterior plates (those between the 4th pair of legs) enclose a more or less semicircular deep cavity. Between the 3rd pair of legs there is a pair of teeth and between the 2nd pair two spines. The coxæ of the 3rd and 4th legs are prolonged inward and the upper surface of each prolongation carries a sharply defined spherical cavity. The structure of the thelycum, however, is not constant (Text-fig. 14 *a*, *b*). The two plates between the 5th pair of legs may be widely separated from each other or may be so close as to give the impression of one plate, such as is the case with the thelycum figured by Tattersall. The two pieces which form the 2nd plate (between the 4th pair of legs) may be completely separated, or be partially or completely fused. The concavity between the two anterior plates may be circular or nearly so. The external piece of the right petasmal endopodite is large, but is shorter than the left external piece, which is slender and divided into three lobes anteriorly (Text-fig. 14 *c*). Nobili writes that this divided part is enclosed in a membrane, but I am unable to find this membrane in any of the males that I have examined.

Distribution.—Red Sea.

Penæopsis (*Metapenæus*) *faouzii* sp. nov. (Text-fig. 14 *d*.)

Occurrence.—Sta. 161, Maldive area, depth 46 m.; 2 females, each 50 mm. in length.

This species is closely related to *P. vaillanti*. The integument is thick, hard and tomentose. The rostrum is obliquely ascending, with both edges straight. It reaches the end of the 2nd segment of the antennular peduncle. In one specimen it carries eleven teeth and in the other nine besides the epigastric one. The post-rostral carina does not extend beyond the gastric region. The carapace carries a small orbital spine and a large antennal one, and the antero-inferior angle is prolonged into a large spine. The sub-hepatic groove, which resembles that figured by Alcock for *P. mogiensis*, is well developed. The pleura of the 1st abdominal segment overlap the end of the carapace. The 1st and 2nd segments are not carinate, the 3rd–6th are so. The carina on the 3rd segment is sulcate, those on the 4th–6th are sharp; on the 4th and 5th segments the carina is deeply cleft posteriorly and on the 6th it ends in a spine. The 5th segment is $\frac{3}{5}$ as long as the 6th, the latter being $\frac{2}{3}$ as high as long and shorter than the telson, which is almost as long as the uropods, and carries one pair of immovable spinules and three movable ones. The carapace is about half as long as the 6th abdominal segment. The external maxilliped reaches the end of the scaphocerite. The 3rd pair of legs reach the end of the 1st segment of the antennular peduncle. The thelycum (Text-fig. 14 *d*) consists of the following: a plate between the 5th pair of legs, which is cut into three lobes, as in other species; a plate between the 4th pair of legs, which is divided into two unequal parts; an anterior large part, with a concave upper surface and a small narrower one with a small rounded tubercle posteriorly on either side. Between these two plates there is a transverse plate with a concave posterior edge. There is a pair of sternal spines between the 3rd pair of legs. The thelycum differs from that of *P. mogiensis* by the absence of the divergent median teeth between the 4th pair of legs which characterize *P. mogiensis*, *P. distinctus* and *P. perlarum*.

Genus *Parapenæus* Smith.

Burkenroad, 1934*a*, p. 107.

In his redefinition of the genus Burkenroad (*loc. cit.*) writes, " a distal pair of fixed lateral teeth on the telson preceded by a pair of minute mobile spines " ; and on p. 108 " Schmitt's statement that ' the telson of *Parapenæus* is without movable spines ' is incorrect ". Besides the species of *Parapenæus* collected by the John Murray Expedition, specimens of *P. longipes*, *P. investigatoris*, *P. fissurus* and *P. longirostris* were examined by me in the British Museum. In not a single specimen of this extensive material have I been able to detect the presence of mobile spinules. I have therefore consulted Dr. Burkenroad on this point, and he informs me that " the mobile spinules on the telson of *P. longirostris* is not constantly present, but is found in the majority of American specimens, as well as in the large examples from the Mediterranean available. . . . The occurrence of mobiles in the generic type was emphasized because the presence of a mobile armature in *Penæopsis* might otherwise have been granted great significance ". I would note also that the fixed spine which occurs on the inner edge of the ventral side of the basal segment of the antennular peduncle is minute in the material examined and much smaller than the corresponding ones in *Penæopsis.*

The species of *Parapenæus*, according to the definition of Burkenroad, are six : *P. longirostris* (Lucas), *P. americanus* Rathbun, which inhabit the Atlantic, the former occurring in the Mediterranean too, *P. longipes* Alcock, *P. investigatoris* Alcock & Anderson, *P. fissurus* (Spence Bate) and *P. murrayi* sp. nov., these last four species inhabiting the Indo-Pacific region.

Parapenæus fissurus (Spence Bate).

Parapenæus fissurus, Alcock, 1906, p. 31, pl. v, figs. 16, 16*a* and *b*.

Occurrence.—(1) Sta. 105, Zanzibar area, depth 238–293 m. ; 6 females, 2 males.

(2) Sta. 106, Zanzibar area, depth 183–194 m. ; 2 males.

In possessing a double curve the rostrum agrees with the description given by De Man (1911, p. 79). There are no epipodites on the 3rd legs, or movable spinules on the telson ; exopodites are present on all the legs, but those of the last three pairs are very minute. The spine on the inner edge of the ventral side of the basal segment of the antennular peduncle is very small.

Distribution.—Indo-Pacific region.

Parapenæus investigatoris Alcock & Anderson.

Parapenæus investigatoris, Alcock, 1906, p. 32, pl. vi, figs. 17, 17*a–c*.

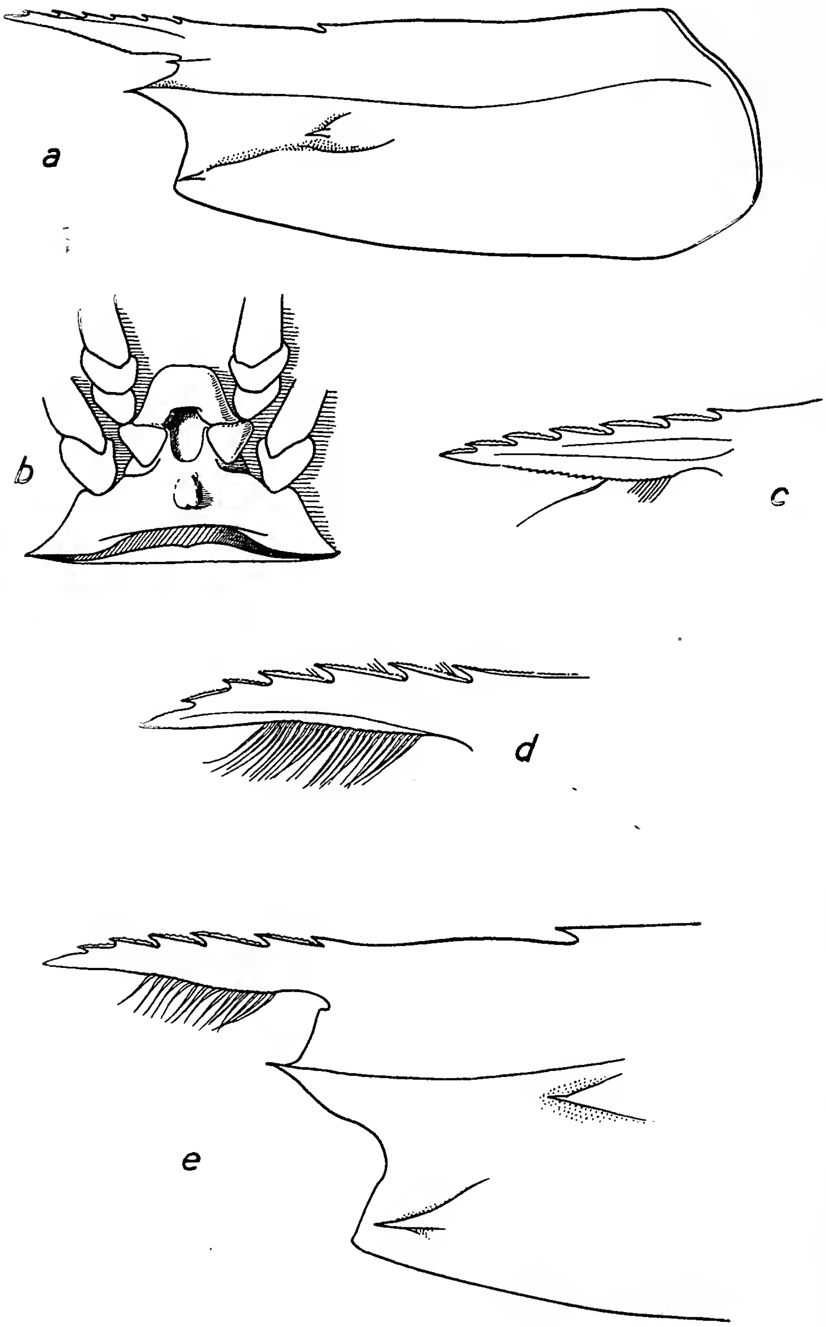
Occurrence.—Sta. 194, Gulf of Aden, depth 220 m. ; 14 females, 3 males.

The rostrum shows a distinct convexity, its tip being directed downward, and the ventral edge is distinctly concave. There are no epipodites on the 3rd legs, no exopodites on any of the legs, and no movable spinules on the telson.

Distribution.—Indo-Pacific region.

Parapenæus murrayi sp. nov. (Text-fig. 15 *a–c*.)

Occurrence.—Sta. 105, Zanzibar area, depth 238–293 m.; 18 females, 12 males. The largest specimen is 60 mm. long.



Text-fig. 15.—*Parapenæus murrayi* n. sp. *a*, Carapace, × 5·3. *b*, Thelycum. *c*, Rostrum, × 8·3. *Parapenæus investigatoris* Alcock & Anderson. *d*, Rostrum, × 10. *e*, Front of carapace, × 8·7.

This species is closely related to *P. investigatoris*, from which it is separated by a number of characters mentioned below. The rostrum (Text-fig. 15 *a*, *c*) is obliquely ascending, with both edges straight. It carries six or seven teeth besides the epigastric one, and reaches to just beyond the eyes, but not to the end of the 1st segment of the antennular peduncle. The post-rostral carina stops abruptly at the middle of the carapace. A branchiostegal spine is present (above and behind the antero-inferior end of the carapace). The 1st pair of legs carries a spine on both the ischium and basis, no exopodites are present on any of the legs, and no epipodites on the last three pairs of legs. The 4th–6th abdominal segments are sharply and thinly carinate, each carina ending acutely; that of the 4th segment does not extend the whole length of the segment. The 6th abdominal segment is more than twice as long as the 5th, longer than the telson and just shorter than the carapace. The telson is much shorter than the inner rami of the uropods, and carries one pair of fixed spines but no movable ones.

The thelycum (Text-fig. 15 *b*) is built on the same plan as in *P. investigatoris*. The transverse semicircular plate between the 4th pair of legs in *P. investigatoris* is supported on two pillars, between which posteriorly is a tubercle and the whole organ encloses an 8-shaped fossa. In this species the two pillars unite posteriorly and carry a tubercle on that part. The 8-shaped fossa is absent. The petasma is completely similar to that of *P. investigatoris*.

This species is thus distinguished from *P. investigatoris* by the following characters :

1. The rostrum is obliquely ascending, with both edges straight, while in *P. investigatoris* (Text-fig. 15 *d*) it is convex. The post-rostral carina stops at the middle of the carapace, while in *P. investigatoris* it fades away in the posterior 4th of the carapace.

2. The 6th abdominal segment is, in comparison with the 5th, longer than it is in *P. investigatoris*. In the latter species it is equal to, or but little more than, twice the length of the 5th, and is much shorter than the carapace.

3. The structure of the thelycum differs in the two species, as described above.

Sub-family Eusicyoninæ Burkenroad.

Eusicyonia Stebbing.

Eusicyonia carinata (Olivier).

Sicyonia carinata, Milne-Edwards and Bouvier, 1909, p. 244; Balss, 1925, p. 232, fig. 8.
Sicyonia sculpta, Spence Bate, 1888, p. 294, pl. 43; De Man, 1911, p. 10.
For the rest of the synonymy, see Balss (*loc. cit.*).

Occurrence.—Sta. 106, Zanzibar area, depth 183–894 m.; 2 males.
Both examples were about 40 mm. in length.

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BRITISH MUSEUM (NATURAL HISTORY)

THE

JOHN MURRAY EXPEDITION

1933–34

SCIENTIFIC REPORTS

VOLUME V, No. 4

A SYSTEMATIC AND ANATOMICAL ACCOUNT OF THE OPISTHOBRANCHIA

BY

N. B. EALES, D.Sc.
(*Zoology Department, University of Reading*)

WITH ONE PLATE AND TWENTY-EIGHT TEXT-FIGURES

LONDON:
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SOLD BY
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H.M. STATIONERY OFFICE, LONDON, S.W.1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
1938

Price Five Shillings

[*Issued 16th April, 1938*]

DESIGNED AND
PRINTED
BY
ADLARD & SON, LTD.
21, HART STREET, W.C.
AT
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DORKING

Made and printed in Great Britain

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INTRODUCTION.

The Opisthobranchs collected by the John Murray Expedition consist of 23 species belonging to 18 genera, and include both Tectibranchs and Nudibranchs. In geographical range they belong to the Red Sea, Gulf of Aden and South Arabian coast as far east as Maskat. Their vertical range is from the surface (*Stylocheilus*) to 220 metres (*Pleurobranchoides*. *Armina*).

Many of the specimens are very small representatives of their species, *e.g. Asteronotus hemprichii*, which attains a length of 90 mm. or more, is in this collection only 32 mm. long. Small animals are often immature, and in some cases it was difficult to decide the species owing to imperfect development, particularly of the reproductive apparatus. Most of the specimens were well preserved internally, though a few (*e. g. Pleurobranchoides, Glossodoris*) were torn or macerated before preservation. Many had lost all or nearly all their colour, and it would be helpful for future work if some record of the living animal, at any rate of the larger specimens, could be made before the colour disappears. The painting made by Colonel Sewell of the handsome carmine and white *Hexabranchus sanguineus* was a useful confirmation of the results of anatomical investigation, in a Nudibranch whose radular characters are somewhat variable, and whose colour varieties have been divided by many authors into different species.

For the determination of the species of most of the Opisthobranchs anatomical study is a necessity. The specimens were opened from the ventral surface under a Zeiss binocular dissecting microscope so that the dorsum remains uninjured. Many were photographed before dissection, and wherever possible anatomical details were drawn under the Edinger projection apparatus. A few were injected, others stained temporarily with safranin to facilitate investigation. In describing the general anatomy an attempt has been made to utilize characteristic features for comparative purposes, chiefly with regard to the nervous and reproductive systems. In the past much confusion has resulted from an investigation of *parts* of the organs, severed from their connection within the body, and unaccompanied by any figure of the entire animal. It is hoped that the photographs and sketches in the present report will be of use not only to the systematist, but also to the comparative anatomist.

My thanks are due to Colonel Sewell and Dr. Calman for giving me the opportunity of examining and reporting on the collection. Mr. R. Winckworth has been most helpful in criticizing and advising me in my work and in suggesting and lending literature. To the British Museum authorities I am indebted for the publication of the Report.

LIST OF OPISTHOBRANCHS REPRESENTED IN THE JOHN MURRAY COLLECTION.

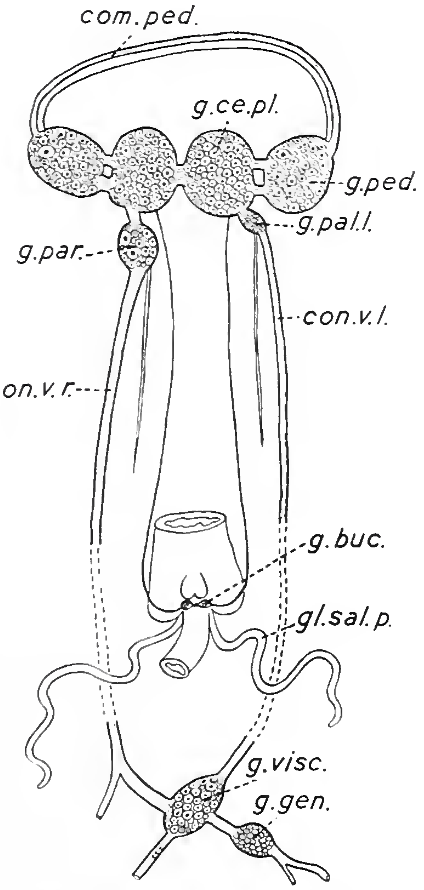
TECTIBRANCHIA	Cephalaspidea	Hydatinidæ	*Hydatina velum* (Gmelin).
		Bullidæ	*Bulla ampulla* Linn.
		Atyidæ	*Atys naucum* (Linn.).
			A. cylindrica Helbling.
			Atys sp.
			Phanerophthalmus collaris sp. nov.
	Anaspidea	Aplysiidæ	*Stylocheilus longicaudus* Quoy & Gaimard.
	Notaspidea	Pleurobranchidæ	*Pleurobranchoides* sp.
NUDIBRANCHIA	Doridomorpha	Hexabranchidæ	*Hexabranchus sanguineus* (Rüppell & Leuckart).
		Polyceridæ	*Nembrotha lineolata* Bergh.
		Doridæ.	
		Glossodoridinæ	*Glossodoris* sp.
		Doridinæ	A Dorid.
		Discodoridinæ	*Discodoris* sp.
		Asteronotinæ	*Halgerda willeyi* Eliot.
			H. apiculata (Alder & Hancock).
			Asteronotus hemprichii Ehrenberg.
			Asteronotus sp.
		Arginæ	*Artachæa intermedia* sp. nov.
		Phyllidiidæ	*Phyllidiella pustulosa* (Cuvier).
	Eolidomorpha	Arminidæ	*Dermatobranchus striatus* v. Hasselt.
			Armina semperi (Bergh).
			A. tæniolata Bergh.
		Scyllæidæ	*Scyllæa pelagica* Linn., var. *orientalis* Bergh.

Hydatina (*Aplustrum*) *velum* (Gmelin). (Text-fig. 1; Pl. I, fig. 8.)

Aplustrum velum, Bergh, S.R.,* 1901, p. 242, taf. 20 and 21; Vayssière, 1906, p. 29, pl. iii, figs. 52–54; pl. iv, fig. 55.

OCCURRENCE.—Sta. MB II (*a*). Arabian coast, 11 metres; one specimen, 15 mm. long, 10 mm. wide, the shell 9 mm. high.

DISTRIBUTION.—Pacific and Indian Oceans.



TEXT-FIG. 1.—*Hydatina velum*. The nervous system viewed from the ventral side. The full length of the visceral cords is not shown; they are nearly twice as long as in the figure. × 14. (For explanation of reference letters used in the Text-figs. see list at p. 119.)

DESCRIPTIVE NOTES.—The external features and shell of this beautifully-marked species are well known, and both Bergh and Vayssière have described the internal anatomy. Only certain features regarding the gut and nervous system are therefore described here.

The alimentary canal is remarkable both for its length and its contents. On opening up the body from the ventral side, it was seen that a voluminous crop with extremely thin walls filled the greater part of the body cavity. Through the wall glistening setæ were visible, and these proved to be those of a Cirratulid worm, 80 mm. long and 4 mm.

* The initials S.R. refer throughout this Report to the publication, 'Semper's Reisen im Archipel der Philippinen',

wide, more than five times as long as the *Hydatina* which swallowed it. Bergh noted a similar worm in his specimen, so that the mollusc is probably highly selective in the choice of its food. The buccal mass is of astonishing length, being 30 mm. long and coiled up on the right side of the body, where it is pushed owing to the amount of food in the crop. It consists of a long muscular tube, little varied in width along its length. The posterior end is rounded, and from its ventral wall projects a small bilobed radular sac. The whole apparatus is moored by slender retractor tendons to the body wall, and the radular portion is attached to the oral portion by a pair of tendons. The nerve ring surrounds the buccal mass anteriorly, close to the external aperture. As in the Bullidæ, the pedal commissure is the most anterior part of the ring. The buccal ganglia lie near the radular sac, so that the cerebro-buccal connectives are long, though as they are considerably shorter than the buccal tube itself, it can be inferred that the tube cannot be fully extended. There are two pairs of salivary glands. The anterior pair, sometimes called the ptyalin glands, are fastened posteriorly by connective tissue to the sides of the buccal mass and discharge anteriorly near the mouth aperture. They form rather thick tubes. The posterior glands are very slender, sinuous structures opening into the pharyngeal groove on the dorsal side of the buccal mass. The œsophagus is at first narrow, but soon expands into a very large crop, which contracts again to form the stomach. There is no gizzard. The stomach is surrounded by the digestive gland, and receives several large bile ducts. The intestine is relatively short and the anal aperture lies on the summit of an anal tube. The buccal mass contains jaw plates and a rather small radula. The hooked rods of the former and the elongated 3- or 4-toothed plates of the latter have been clearly depicted by Bergh (S.R. 1901, Taf. 20, fig. 47 and Taf. 21, figs. 1–7). The formula for the specimen is 15.0.15, and there are 28 rows of teeth. On the naked rachis is a very minute flat plate, which may represent a vestige of the rachidian tooth.

The nervous system (Text-fig. 1) exhibits a more highly concentrated condition than that of the Bullidæ, though similar elements can be traced in it. The most anterior portion of the nerve ring is the double pedal commissure. The pedal ganglia are, however, in a line with the cerebral, and since the cerebral commissure is extremely short, all the ganglia lie towards the dorsal side, in contrast to their lateral position in the Bullidæ. The cerebral mass evidently represents a fusion of cerebral and pleural ganglia, as it is linked with the pedal ganglion by two connectives. Moreover, the pleuro-visceral cords emerge from the posterior or pleural portion of the mass. The left cord enlarges almost at once into a small ganglion which gives off a nerve dorsally. This is the left pallial ganglion (*g. pal. l.*). The course of the cord is beside the gut as far as the posterior border of the large crop. It then crosses the gut ventrally and here forms a large ganglion, representing the fused infra-intestinal and visceral ganglia (*g. visc.*). A stout nerve with a few odd nerve cells near its origin travels to the columellar muscle ; a small nerve passes to the left beside the hermaphrodite duct and forms the usual genital ganglion (*g. gen.*) and genital nerve. The right pleuro-visceral cord has a large ganglion near its exit from the cerebro-pleural mass. This ganglion gives off a slender nerve which forms a pair with that from the left pallial ganglion, whence the inference is that the ganglion has been formed by fusion of right pallial and supra-intestinal ganglia (*g. par.*). The cerebro-buccal connectives pass backwards to the pair of small buccal ganglia (*g. buc.*) situated in their usual position close to the radular sac. All the ganglia are enclosed in connective-tissue capsules.

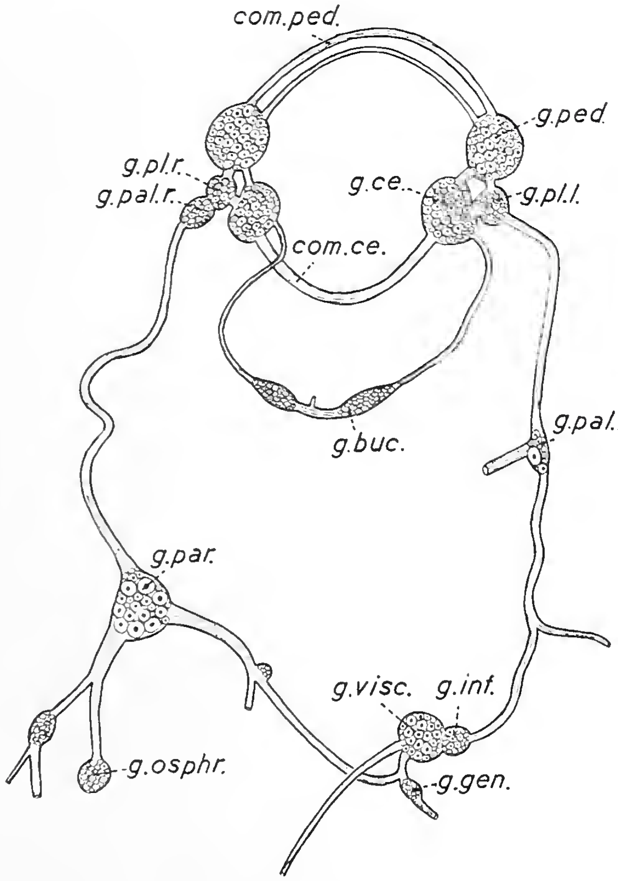
Bulla ampulla Linn. (Text-fig. 2.)

Bulla ampulla, Bergh, S.R., 1901, p. 210, taf. XVIII, figs. 9–25; Vayssière, 1906, p. 18, pl. ii, figs. 27–33.

Occurrence.—Sta. MB II (*a*). Coastal zone, Arabian coast, 28.x.33, 9 metres; one specimen, whose shell is 18 mm. long, 11 mm. wide and 9 mm. high.

Distribution.—Coasts of India and Eastern Africa.

Descriptive Notes.—The external features and shell of this species are well known. In its jaw rods, radula and gizzard plates the specimen agrees with the type. The radula



Text-fig. 2.—*Bulla ampulla.* The nervous system viewed from the ventral side. The supra-intestinal ganglion is dorsal to the gut, the infra-intestinal and visceral ganglia lie ventral to it. × 14.

had 20 rows of central teeth, but only 18 rows of laterals, the formula being 3.1.3. The outermost lateral is a simple plate without cusp or denticles; the second lateral is denticulate on one side and the first lateral on both sides. As neither Bergh nor Vayssière gives a description of the nervous system, an account is here appended. The nervous system (Text-fig. 2) exhibits a primitive separation of the main ganglia of the nerve ring, while at the same time showing certain specialized features. The nerve ring consists of paired cerebral, pleural and pedal ganglia, and on the right side a small pallial ganglion (*g. pal. r.*) follows the pleural ganglion. The cerebral ganglia are very widely spaced, and both the cerebral and the double pedal commissures are very long. The most anterior ganglion of the set is the pedal, the most posteriorly placed the cerebral, while the pleurals are lateral. Cerebro-pleural, cerebro-pedal and pleuro-pedal connectives are distinct. The cerebro-buccal connectives are long, and allow of considerable movements backwards and forwards of the buccal mass. In the specimen, owing to strong retraction of the buccal mass, the buccal ganglia (*g. buc.*) lie posterior to the nerve ring, but when the mass is thrust forwards, they would be carried with it through the ring. The cerebral ganglia, however, are fixed in the position they occupy postero-dorsal to the pedal ganglia, a situation which may be related to the backward position of the rhinophores. From the right pleuro-pallial ganglionic centre a connective passes alongside the gut, but slightly towards its dorsal side, swelling near the gizzard to form a large flat supra-intestinal ganglion (*g. par.*). From this two nerves arise, of which the *lateral* supplies the osphradium, becoming ganglionated immediately beneath that organ. A dorsal branch, also ganglionated, runs towards the anus. The *mesial* division bears a few nerve cells, and passes over the ventral side of the gut towards the left cord. From the left pleural ganglion a connective passes backwards, beside the left side of the gut at first, then crossing the gizzard ventrally it converges towards the right connective. I was unable to follow the connection between right and left cords owing to a break in this region, but dissection of a specimen of *Bulla striata* enabled me to trace it, and it may be assumed to exist in *B. ampulla*. About half-way down the left connective is a very small pallial ganglion (*g. pal. l.*), from which a nerve goes dorsalwards to the body wall. On the ventral side of the gizzard are two contiguous ganglia, the first a rather small infra-intestinal (*g. inf.*), the second a much larger visceral ganglion (*g. visc.*). From the latter two nerves arise, of which one turns postero-ventrally and splits into two, a genital nerve, and the nerve which presumably joins its fellow connective. The genital nerve runs beside the hermaphrodite duct after passing through a small genital ganglion (*g. gen.*). The other branch from the visceral ganglion travels postero-dorsally along the columellar muscle, which it supplies.

Atys naucum (Linn.).

A. cylindrica Helbling.

Atys sp.

Occurrence.—Sta. MB I (*b*), Red Sea, 17.ix.33, 29 metres.

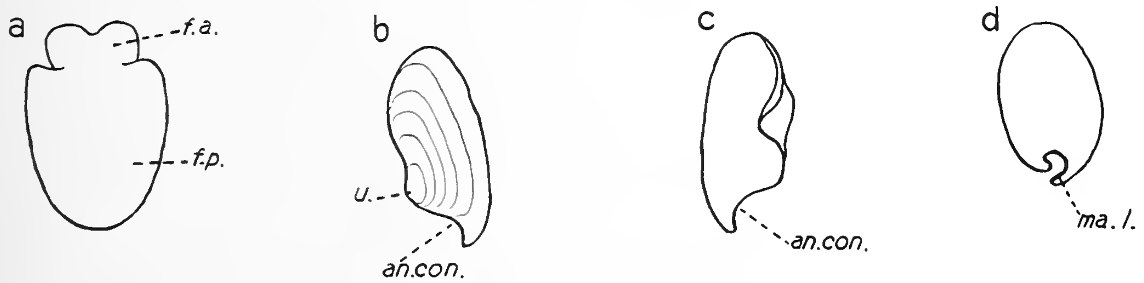
Four dead shells, one of *A. naucum*, 15 mm. long, two of *A. cylindrica* 12 mm. and 4 mm. long respectively, and one of a more heavily built species only 3 mm. long.

Phanerophthalmus collaris sp. nov. (Text-figs. 3–6; Pl. I, fig. 2.)

Occurrence.—No station was given, but the date, 12.x.33, and depth, 15 to 40 fathoms, indicate that the specimen must have been taken at Sta. 27, Gulf of Aden, near Cape Guardafui, depth 37–91 metres.

Descriptive Notes.—Length 8 mm., breadth 6 mm., height 3·5 mm. Of a broadly oval shape, wider anteriorly than posteriorly, though the posterior end is rounded. The body is soft, without papillæ or tentacles. It is greenish in colour, except where the dark viscera show through the dorsal surface. The two large, circular, intensely black eyes shine through the skin of the cephalic shield. Postero-dorsally lies a porcellaneous white shell, 3·5 mm. long and 2 mm. wide, apparently external, and with its lines of growth running longitudinally, the umbo on the left (Text-fig. 3*b* and *c*). At this side the shell is thicker, but there is no trace of a spiral. The posterior border is incised for the passage of the anus. The edges of the shell are yellow. A very thin, transparent mantle covers it, but the covering is so delicate that the shell was at first thought to be external. Only on attempting to move the shell was it found to be held in place by the mantle, so that, as in other species of *Phanerophthalmus*, the shell is internal or intra-pallial.

The body is depressed, flatter dorsally than ventrally, where the foot, devoid of a pedal sole, is rounded in transverse section. This flattening of the dorsal surface reaches its extreme in the cephalic shield, which is no more than a thin flap, slightly broader than long, notched deeply on its anterior rounded border, and curving inwards posteriorly, but not reaching the middle line, where a gap about 1 mm. wide occurs. Thus the cephalic shield overhangs the body anteriorly and laterally, and, in part, posteriorly. The black eyes shine through the dorsal side of the shield at about its centre. Postero-laterally the shield overlaps and is fastened to a pair of structures shaped like epaulettes—small brown triangular flaps which run up under the sides of the shield for a short distance. The

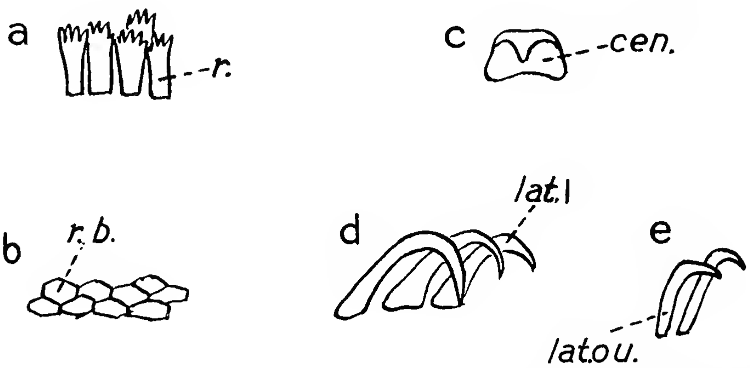


TEXT-FIG. 3.—*Phanerophthalmus collaris*. *a*, Foot to show anterior and posterior divisions. × 3. *b*, Shell from the dorsal side. × 7. *c*, Shell, ventral view. × 7. *d*, Mantle, to show lappets and anal (pallial) aperture. × 7.

ventral surface of the flap consists of from 12 to 15 filaments set transversely and somewhat obliquely. These organs are the rhinophores, called the osphradia by some authors, but homologous with similar structures in the Bullidæ, etc. The head bears no distinct tentacles, but under the overhanging anterior bilobed flap of the shield is a pair of ridges, in the same position as the larger ridges in the Bullidæ. These may be vestiges of oral tentacles. Connecting the rhinophore flaps is a faint transverse ridge on the dorsum. This may be a separated portion of the cephalic shield, but it is indistinct in the specimen. The dorsal body wall is ridged transversely. Posteriorly, almost in the middle line, is the anus, postero-dorsally the shell, and on the right postero-laterally a plumose ctenidium, whose apex is directed backwards. The external genital aperture is covered by the ctenidium, and from the aperture an open seminal groove runs forward along the whole length of the right side of the animal to the penis, situated on the right side of the head.

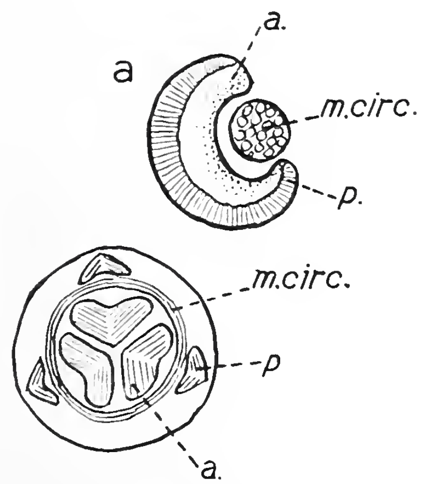
The foot is flabby, without defined creeping surface. It is divided into two portions, anterior and posterior, by deep lateral incisions (Text-fig. 3*a*). The anterior portion lies beneath the cephalic shield and is similar to it in size and shape. Anteriorly it reaches to the foremost limit of the shield, and its anterior border is bilobed to match the latter. The posterior portion is about four times as long as the anterior, and is also much wider. Its sides are prolonged into a pair of parapodia, which curve dorsalwards over the back, but are not long enough to hide the shell and dorsum. The lateral seminal groove, genital aperture and ctenidium may, however, be covered. Anteriorly this portion of the foot forms a kind of upstanding collar round the body; posteriorly the parapodia are fused and drawn tightly over the posterior end of the body, so that they make a secondary pallial cavity. From the above description it is obvious that the foot is longer than the body owing to this posterior extension. The mantle, on the other hand, is very small (Text-fig. 3*d*). It encloses the shell as a thin transparent layer, but its posterior border is thickened, and prolonged into two unequal processes which curve round the anus and form the outlet for the reduced pallial cavity. The right process, which is longer and more curved than the left, is partly supported by the beak of the shell, into the concavity of which the anus fits.

The alimentary canal resembles that of other members of the family in its general features. The buccal mass is well developed, though the jaws and radula are very slender and small. Each jaw plate is hemispherical and bears about 20 rows of very minute rods.



TEXT-FIG. 4.—*Phanerophthalmus collaris*. *a*, Five rods from the jaw. Lateral view. × 500. *b*, Bases of the jaw rods. × 500. *c*, Rachidian tooth of the radula. × 500. *d*, First three lateral teeth. × 500. *e*, Two outer laterals. × 500.

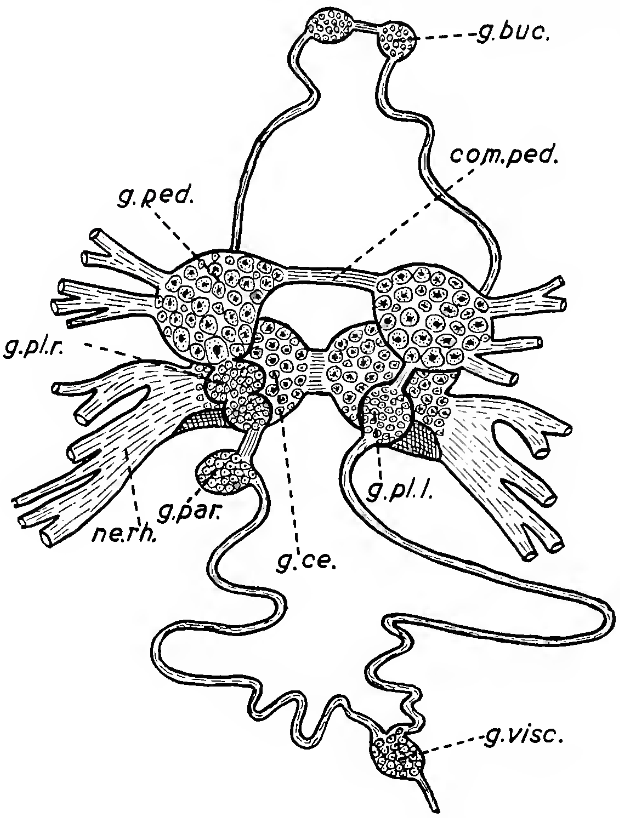
On the under-surface these rods, owing to their regular arrangement in alternate series, present a tesselated appearance (Text-fig. 4*b*); on the upper surface each rod broadens to form a curved and overlapping surface for the next rod, the free edge being provided with four or five finger-shaped denticles (Text-fig. 4*a*). The broadening of the rods at the free end is peculiar. The radula is very small, and its narrowness in the specimen was exaggerated by rolling of the edges. In attempting to flatten it, some dislocation of the teeth occurred. As far as could be ascertained there are 20 rows, with an average formula of 12.1.12, though some rows have a few more teeth than this. The central (Text-fig. 4*c*) is a very small tooth, with an almost square thin base and a single narrow pointed cusp, on which no denticles could be seen. The laterals (Text-fig. 4*d* and *e*) are all alike, differing only in the length of the slender cusp. The base is narrow, without a shoulder, the whole of it bending over to form the curved cutting surface, which slopes towards the centre of the radula. A pair of long, slender salivary glands open into the buccal cavity, and are fastened posteriorly by connective tissue to the gizzard. At this point the œsophagus, just before expanding into the gizzard, bears a small pouch on the right side, but this may be an abnormality. The gizzard is a trifoliate structure situated on the right anterior border of the digestive gland. Its three dark gizzard plates are set longitudinally in the wall, and are bound together by a strong circular band of muscle lying in the gizzard wall. Each gizzard plate (Text-fig. 5*a* and *b*) is thick and arcuate, of a shape common in the family, and marked by two rows of very fine, transversely arranged parallel ridges set in pent-house fashion. The convex side of the plate is directed towards the cavity of the gizzard, the concave side towards its wall. The convex side is also the keeled striated side. Into the concavity fits very neatly the circular band of muscle fibres, which thus not only binds the plates together, but by its contraction brings the grinding surfaces together. Since these grinding surfaces are curved, there will also be a longitudinal movement, whereby crushed food is passed on in a manner recalling peristaltic action in other animals. The bile ducts enter on the dorsal side of the narrow stomach, and the intestine passes ventrally to the left, then loops round dorsalwards and back along the right side towards the posteriorly situated anus. It is embedded in liver tissue although exposed on the surface. The digestive gland is relatively very large, occupying, with the hermaphrodite gland, about two-thirds of the body space.



TEXT-FIG. 5.—*Phanerophthalmus collaris*. *a*, Lateral view of gizzard plate and circular muscle of gizzard. × 10. *b*, Gizzard in anterior view to show the three curved gizzard plates into whose concavity the circular muscle fits. × 5.

The reproductive system is very minute and it was not possible to investigate all the details. The hermaphrodite gland is closely bound up with the digestive gland, appearing here and there on the surface, its whiteness in marked contrast to the brown colour of the latter. The hermaphrodite duct emerges posteriorly close to the point at which the rectum frees itself from the digestive gland. An albumen gland and pear-shaped spermatocyst are present, the latter lying within the terminal coil of the hermaphrodite duct. On the right, close to the kidney and heart, is a globular spermatheca communicating by a slender duct with the vagina. The common genital aperture lies at the anterior end of the ctenidium, and is thus posteriorly placed on the animal's right side. An open seminal groove leads from this to the penis, lying on the right side of the head, beneath the cephalic shield, and at about the transverse level of the eyes. The penis has a very slender retractor muscle, and from the inner end of its sheath arises a long sinuous duct which passes dorsally across the body, enlarging to form an elliptical prostate. The penis is unarmed but bears soft nodular processes.

The nervous system (Text-fig. 6) exhibits several peculiar features. Of the ganglia which encircle the œsophagus, the ventral pedal ganglia (*g. ped.*) are the most anteriorly placed, so that the pedal commissure is actually anterior to the cerebral commissure. The flattening of the head and the position of the eyes and rhinophores far back on the cephalic shield may be responsible for this. A second peculiarity is the thickening of the nerves supplying the rhinophores (*ne. rh.*), and an especially dense region on the posterior border of the main nerve. A third is the asymmetry of the pleuro-visceral group of ganglia. On the right side the pleural ganglion (*g. pl. r.*) is partly divided, and there is a separate ganglion joined to the divided ganglion by a connective. On the left side there is



TEXT-FIG. 6.—*Phanerophthalmus collaris.* Nervous system from ventral side. × 45.

only a single ganglion (*g. pl. l.*). On each side a long connective runs lateral to the digestive gland and joins its fellow postero-dorsally close to the genital complex, swelling into an irregularly-shaped ganglion. From a comparison with other Tectibranchs and from what can be worked out of the innervation of the parts in so small a specimen, the interpretation of these ganglia is as follows: The subdivided ganglion on the right side represents the right pleural and right pallial ganglia; the separated ganglion of that side is the supra-intestinal ganglion (*g. par.*). The ganglion of the left side represents fused pleural and pallial ganglia, while the posterior ganglion at the end of the long connectives is formed from the combined infra-intestinal, visceral and genital ganglia (*g. visc.*). The buccal ganglia (*g. buc.*) occupy their usual place on the ventral side of the œsophagus. Their position relative to the ring will be affected by the movement of the whole buccal mass backwards and forwards. It should be noted, however, that Bergh's fig. 4, taf. 13 in 'Semper's Reisen' (*Cryptophthalmus*) has probably been drawn upside down in an attempt to get the cerebral commissure into an anterior position. That this is an error is shown by the way in which he has threaded the pleuro-visceral connectives through the nerve ring in order to get them into a posterior position. Bergh noted the subdivision of the right pleural ganglion, but did not find a separate supra-intestinal ganglion in *Cryptophthalmus*.

The recorded species of *Phanerophthalmus* are four in number, and all occur in the Pacific area, from New Guinea and the Celebes Sea to Fiji and New Caledonia. *P. luteus* (Q. et G.) (*vide Bulla lutea*, Quoy & Gaimard, 1932, t. 2, p. 369, pl. xxvi, fig. 40 ; *P. luteus*, Bergh, S.R., 1901, p. 297, pl. xxv, figs. 3–22, and 1905, p. 36) has an elongated body, undivided foot, shell hidden, internal, white, longitudinally placed, with the umbo on the left, without a spire, but with a projecting posterior border. Eyes and rhinophores small. Radula broad, 48 rows, formula 32.1.32. From 6 to 30 mm. long, nearly three times as long as broad. Fiji, New Guinea, Celebes Sea. *P. pauper* Bergh (1905, p. 37) has an undivided foot which is bilobed anteriorly. Shell hidden in the mantle, its lines of growth longitudinally placed, without spire, but with projecting posterior edge and umbo on the left. Eyes not visible through the skin. Mantle with two lappets posteriorly. Radula broad, 48 rows, 20.1.20, central with three teeth, 14 mm. long. Celebes Sea. *P. perpallidus* Risbec (1928*b*, p. 39) has an elongated body, undivided foot shorter than the cephalic shield, transparent transversely placed shell with posterior spiral directed towards the *right* side. Eyes distinct. No rhinophores. Radula 50 rows, 12.1.12, 7 mm. long, twice as long as broad. New Caledonia, South Pacific. *P.* (*Xanthonella*) *engelii* (Labbé) (Labbé, 1934, p. 6). Body ovate, foot undivided. Shell intra-pallial, reduced, rectangular, horny, thin and little calcified, placed transversely on the body, with umbo on the *right* and a projecting process. No eyes visible. Rhinophores minute. Radula as above, but no formula given. 10 mm. long, about twice as long as broad. New Guinea.

The present specimen differs from all the above but resembles *P. pauper* in some of its characters. It is, moreover, the first member of the genus to be recorded outside the Pacific area. The name *P. collaris* is proposed for it, and refers to the collar-like parapodial lobes. The species can be thus defined : Body very broad and plump, the breadth considerably more than half the length. Cephalic shield large, divided into anterior and posterior portions. The anterior is broad and overhangs anteriorly and laterally ; the eyes shine through its dorsal surface and it is strongly bilobed over the mouth. The posterior part is narrower and smaller, is fastened to the back and bears the rhinophores laterally. Shell white, longitudinally placed, without spire, but with projecting posterior border and umbo on the left. Covered with a very thin layer of mantle so that it appears to be external. Mantle prolonged backwards round the anus in the form of two asymmetrical lappets, similar to those of *P. pauper*. Foot divided into anterior and posterior portions by a pair of deep lateral incisions. Anterior portion of the foot resembling the anterior part of the cephalic shield in size and shape, posterior portion much wider and prolonged laterally to form a pair of parapodia which stand up round the body, form in front a collar, and fuse behind to provide a secondary pallial cavity. Radula narrow, delicate, about 20 rows, with a formula of 12.1.12 non-denticulate teeth, 8 mm. long, 6 mm. wide. Gulf of Aden.

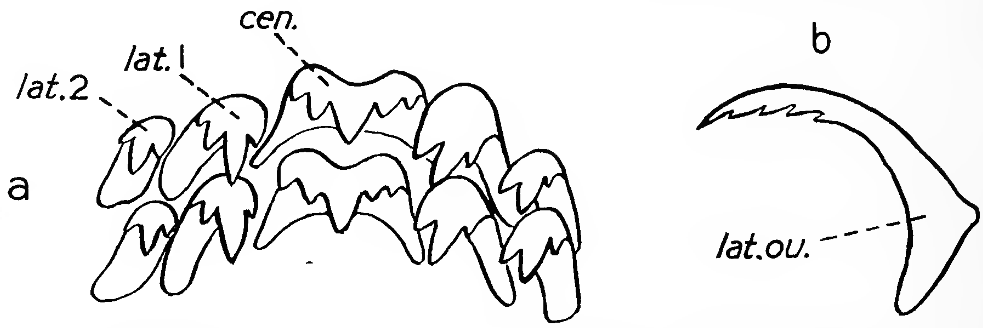
Stylocheilus longicaudus Quoy et Gaimard. (Text-figs. 7–9.)

Aclesia striata, Risbec, 1925*b*, p. 49.
Stylocheilus longicaudus, Engel, 1936, p. 57.

Occurrence.—Sta. 25, Gulf of Aden, near Cape Guardafui, 10.x.33, surface.

Distribution.—Indo-Pacific area from Red Sea to Japan and New Guinea and African coast; Atlantic area, West Indies.

Descriptive Notes.—This tiny Aplysiid measures only 6 mm. in length, 3 mm. in breadth, and 4·5 mm. in height. It has no markings or colour, and owing to the way in which it has contracted, it looks like an *Aplysia* at first sight. But the body is more slender, there is a distinct long tail, the flat, simple lobes of the oral tentacles are better defined, the parapodia are smaller and are fastened tightly on the back. Moreover, the genital aperture is outside the dorsal slit, and since the parapodia are barely 1 mm. apart anteriorly at their point of attachment to the body, the genital groove seems to be very



Text-fig. 7.—*Stylocheilus longicaudus*. *a*, Two rows of teeth from the radula, showing central and the first two laterals on each side. × 400. *b*, Outermost lateral. × 400.

high near its origin. The mantle is reduced, has no aperture, and there is no trace of a shell. On the other hand, the skin exhibits neither papillæ nor definite markings, both of which are characteristic of the genus *Stylocheilus*; but this is a very young specimen, and the colour may have dissolved out. There is a circular spot on the right parapodium which may have been an ocellus.

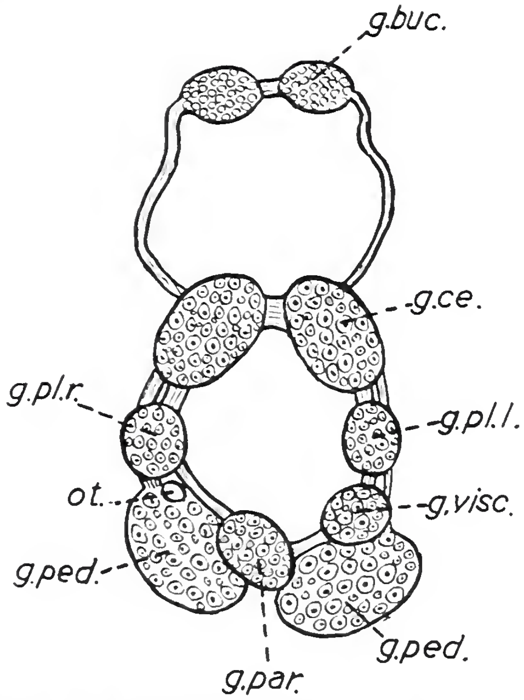
Internally there is no difficulty in identifying the specimen as a *Stylocheilus*, since the characters associated with the radula, the nervous system and the male copulatory apparatus are diagnostic.

The mouth aperture is lined by a folded chitinous layer exhibiting tooth-like structures in two places:

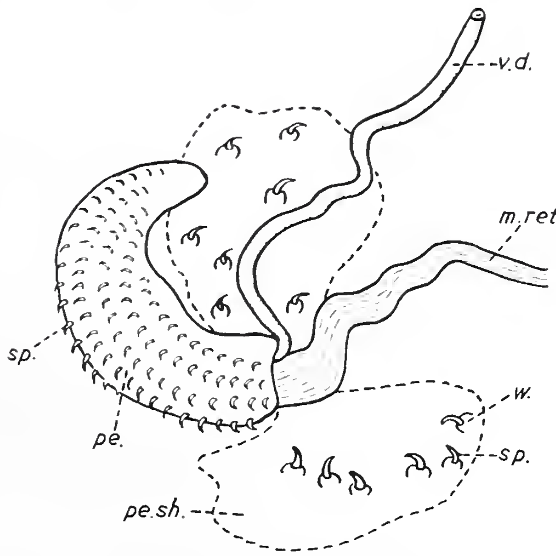
(*a*) Near the entrance are two jaws composed of closely packed rod cells, each cell rather broad and rectangular with an obliquely truncated top or free surface, prolonged at one corner into a small beak. There are about 24 rows of these rods in each jaw plate.

(*b*) Along the walls of the dorsal pharyngeal groove at the point where this leaves the buccal cavity to pass into the œsophagus there are two tracts of spines, consisting of curved hooks directed backwards. The hooks arise from elongated bases, the anterior end of the base, near the convex side of the hook, being prolonged as a shoulder, so that some of the hooks have a bifid appearance.

The radula (Text-fig. 7*a* and *b*) consists of 25 rows of teeth, the first row having a central only, the second row 8 laterals per side, the third 10, the fourth 13, and so on up to a maximum of 20.1.20. The central is on a broad diverging base hollowed out in the



TEXT-FIG. 8.—*Stylocheilus longicaudus.* Nervous system, ventral view. × 52.



TEXT-FIG. 9.—*Stylocheilus longicaudus.* Penis and penis sheath, the latter cut open along the dotted line. × 48.

centre so that the side pieces resemble the legs of an easel. Its anterior portion is also grooved mesially where the base turns over in the cusp. The latter is short and strong, with from 2 to 3 undivided lateral denticles, little smaller than the main cusp. The first lateral is three-pronged and asymmetrical; the remaining laterals increase in length as their distance from the centre increases, but they decrease in strength. They have long narrow recurved cusps with numerous denticles on one side, and they overlap one another so much in the specimen that it is difficult to count them.

The nervous system (Text-fig. 8) is more concentrated than in the Aplysiinæ, although all the ganglia are distinct and rounded, with clear connectives. Cerebral, pleural, pedal and buccal ganglia are grouped round the œsophagus. The pedal commissure is very short. Close to the nerve ring are drawn up the supra-intestinal (parietal) and visceral (infra-intestinal and visceral) ganglia to make an almost symmetrical pair, rather to the right side of the ring. These two ganglia are connected with the pleural ganglia of their own side by pleuro-visceral connectives, and with one another by a visceral connective. Each pedal ganglion has the usual otocyst (*ot.*) lying on its anterior border.

The genital complex is too small for investigation, but the penis (Text-fig. 9) was extracted and mounted. It shows the characters of the genus, being long and narrow, armed all over except at the tip with longitudinal rows of backwardly-directed spines, not set on warts. The preputium or penis sheath is also spiny, but these spines are few in number and each is erected on a wart-like base. There is no penial collar.

Pleurobranchoides sp. (Text-fig. 10*a* and *b*.)

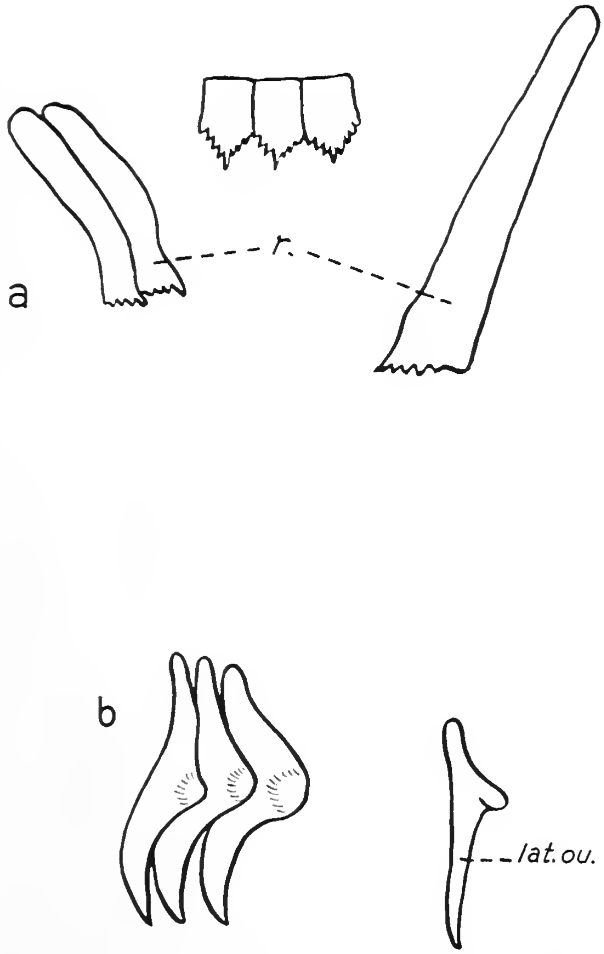
Cf. Pleurobranchoides gilchristi, O'Donoghue, 1928–9, p. 62 ; Eales, 1937, p. 371.

Occurrence.—Sta. 194, Gulf of Aden, 7.v.34, 220 metres ; one specimen, much damaged. Length 85 mm., breadth 65 mm., height 24 mm., but greatly flattened out of the normal. The body must have been plump and elliptical in shape, but the specimen is now in a bad state as though it had been partially decomposed and placed in a rusty receptacle before being immersed in spirit. The notum and side of the body are torn, and most of the internal organs are either badly decomposed or lacerated.

Descriptive Notes.—The skin is smooth, much wrinkled, but without colour or markings. The head is not completely separated from the notum as in many Pleurobranchids ; it is very broad, with widely-spaced anterior (oral) tentacles, 42 mm. from tip to tip. These tentacles, with the fleshy region between them, form a cephalic veil, which is set on a lower level than the notum and has an almost straight anterior border, with the tentacles standing out laterally. There is a constriction between the cephalic veil and the rhinophores, the latter being only 30 mm. apart, short, auriform, and projecting laterally also. The notum commences between the rhinophores in the form of a narrow but steadily increasing fold projecting over the head region, but on a higher level. Its border forms a kind of shoulder laterally, then extends down the sides of the body, overhanging the foot laterally and posteriorly. In other words, the mantle is much larger than the foot, the reverse being the case in *Pleurobranchœa*, though in that genus the general body form is similar. There is no shell. The large bipinnate gill plume on the right side is 40 mm. in length and bears a double row of pigmented nodules on the rachis. The anterior margin of the foot is rounded, with a bifid border. It is 65 mm. long and 35 mm. broad.

The mouth aperture has a pair of very large, dark brown jaw plates, 20 mm. long, 11 mm. broad, very thin anteriorly, but much thicker posteriorly. They are composed of very compact, tall rods, each shaped like an elephant's foot, *i. e.* bent near the broad truncated apex, and extended a little at one corner (Text-fig. 10*a*). The free edge is denticulate, so that each rod is really cusped, with numerous side denticles, the cusp overlapping the next rod. In surface view the plate has the appearance of a piece of plant tissue owing to the extreme regularity of the rods. In this view, by focusing on the short cusps, the latter are found to face all the same way, towards the thick posterior end of the jaw plate.

The radula is very large and dark coloured. It is 22 mm. long and 17 mm. wide, though only 13 mm. wide at the part which is functional. The 40 rows of teeth are much



TEXT-FIG. 10.—*Pleurobranchoides* sp. *a*, Jaw rods in lateral and end views. × 400. *b*, Lateral teeth of the radula. × 150.

curved. The maximum formula of a row is 120.0.120. The centre of the ribbon is naked. The laterals (Text-fig. 10*b*) are all alike, the first 60 increasing in size and strength, the outer 40 decreasing and becoming paler, with thinner and shorter cusps. Finally, the last 20 teeth in the row are curved on the ribbon so that it is almost impossible to make a flat mount of the whole radula without disturbing some of the teeth. The tooth base is narrow and is set almost vertically on the ribbon. There is a blunt, backwardly-directed prong where the cusp leaves the base, and from this a median wing-like strut leaves the base and supports the cusp to its tip, running along its concave surface and gradually narrowing towards the point of the cusp. The cusp is flattened on the convex surface, so that in transverse section it would be triangular. All the laterals are smooth

—that is, they have no denticulations. They resemble very closely those figured in O'Donoghue's *Pleurobranchoides gilchristi*.

The reproductive system is essentially similar to that described by Vayssière in other Pleurobranchids. There is a small compact prostate on the vas deferens, the penis is papillose, but unarmed, and lies in a well-defined sheath. The female duct is large and thick-walled, and receives near its exit an albumen and a mucus gland, while on the opposite side of it lies a spherical spermatheca. There are three apertures into the vestibule, the oviduct, the duct of the albumen and mucus glands and the spermathecal duct. The male and female apertures are close together in a large genital atrium.

There is a very close resemblance between this specimen and that described by O'Donoghue as *Pleurobranchoides gilchristi* from South Africa. Dr. O'Donoghue kindly sent me his two specimens for comparison, together with the radula and jaw plates of one of them. His specimens came from a depth of 340 metres; the larger was 66 mm. long, or about three-quarters the size of the Aden specimen. The external appearance is very similar, except that the ctenidium of *P. gilchristi* is relatively smaller, but this difference may be due to contraction. The jaws and their rodlets resemble those of the Aden specimen closely. O'Donoghue describes a radula of 34 rows and a formula of 110.0.110, with a naked rachis. The present specimen with its 40 rows and formula of 120.0.120 is built of similar teeth, though the radula as a whole is less highly chitinized, and the rachis does not show the vestigial inner laterals of O'Donoghue's specimen. The differences are, however, slight, and there is little justification for claiming them as specific. No other species of *Pleurobranchoides* is known, but since the Aden specimen is imperfect, it is impossible to assess all its characters, and hence no specific name can be given to it.

Hexabranchus sanguineus (Rüppell & Leuckart). (Text-figs. 11, 12.)

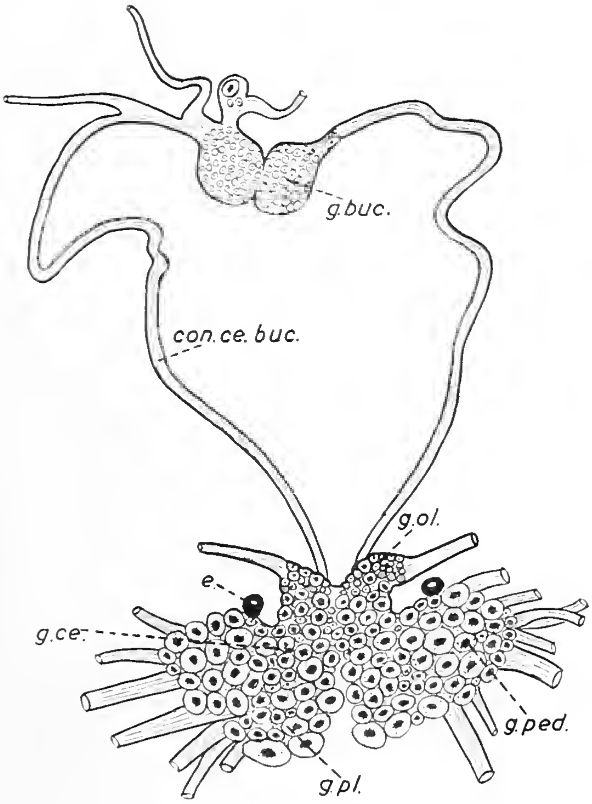
Doris sanguinea, Rüppell & Leuckart, 1828, p. 28.
Hexabranchus faustus, Bergh, S.R., Bd. ii, heft 13, pp. 547–566; Hägg, 1904, p. 5; Eliot, 1904, p. 270, and 1908, p. 98; Vayssière, 1912, p. 16.

Occurrence.—Sta. 10, Red Sea, near Aden, 17.ix.33, 55 metres; one specimen, 65 mm. long, 57 mm. broad and 26 mm. high, foot 48 mm. long and 15 mm. broad.

Distribution.—Red Sea, Indian and Pacific Oceans.

Descriptive Notes.—The specimen bore no trace of colour, but Col. Sewell supplied me with a colour sketch which he made from the living animal. This showed that the colour was bright carmine, with a light edge to the mantle, the red alternating with white on the mantle rim. The branchiæ were a paler red, the rhinophores and their sheaths a yellowish orange. The skin is smooth and soft, without tubercles. There is a wide mantle skirt extending all round the body and thinned and frilled on the edge. The body is rather flattened and soft. The rhinophores are protected by a smooth-edged vallum or sheath. They are foliate and widely spaced, being about 21 mm. apart. The branchiæ are in seven bunches, one bunch being smaller than the others. They are trifoliate and are almost but not completely contractile into a cup. The anus is central within the branchial ring, the renal aperture is on the left and there is a small pore on the right. The foot is rather narrow and very tough; it is much contracted and is thrown into folds. Its anterior border is narrower than the rest of the foot. The mouth is circular, with large flap-like oral tentacles projecting laterally over the mouth. In contraction these tentacles have a crenated outline. The genital aperture is on the right side.

The jaws are well developed, and consist of numerous rodlets, which are tall and curved. A pair of strap-like salivary glands are present. The radula is very broad, dark-coloured and strong, measuring about 10 mm. in length and breadth. All the teeth are simply hooked. There are 41 rows, with a maximum formula of 65.0.65. The centre of the ribbon is entirely devoid of teeth and is clear. As the rows of teeth are much curved and there is a deep declivity in the middle section of the radula, the inner

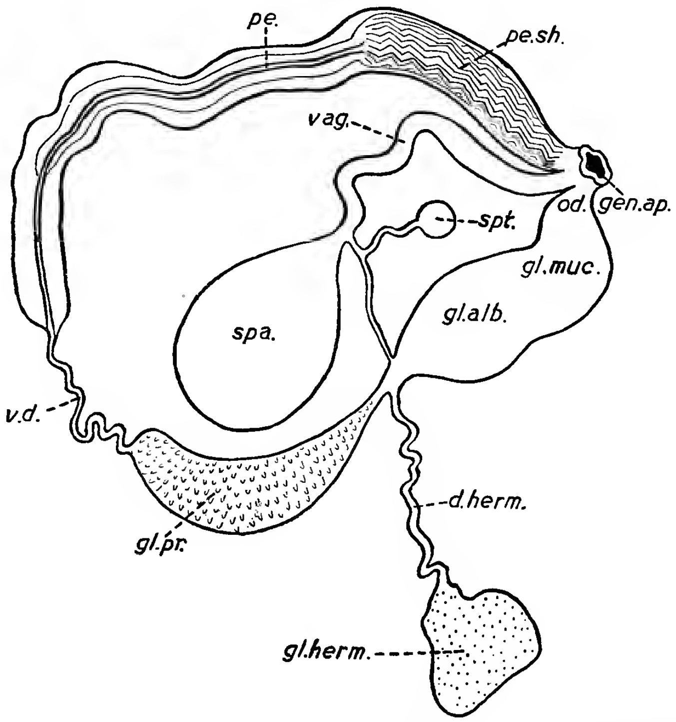


TEXT-FIG. 11.—*Hexabranchus sanguineus.* Nervous system, dorsal view. × 12.

laterals tend to close over the gap. These inner teeth are small, but increase gradually up to the middle of a row, then decrease towards the outer end of the row. The outermost teeth are not, however, degenerate. I have never seen a more worn radula. Some of the teeth have the cusps blunted and very irregularly shortened, others are worn to the base. As the crop was filled with Foraminifera, worm tubes and pieces of Gastropod and Echinoderm shells, the diet is probably the cause of the abrasion. The first lateral is small and may have a cusp or may be imperfect. The cusps of the first 20–25 teeth increase in length, but narrow to fine hooks as their distance from the centre increases. The middle teeth of the row have the largest and strongest cusps, but after this the cusps shorten and become stouter, while the bases of the teeth become progressively smaller. There is an increase also in the obliquity of the base, whereby the cusps, instead of being curved, gradually acquire a straight form and erect position.

The œsophagus enlarges into a voluminous crop, full, as above stated, of animal remains. The stomach is small, with large bile ducts. The intestine leaves on the left, and bends round dorsalwards and to the right, finally becoming mid-dorsal as it nears the anus.

In the reproductive system (Text-fig. 12) the common hermaphrodite duct has a slight ampulla. It divides into male and female portions, the former passing through a prostate wrapped round the spermatheca, with a very long coiled vas deferens and long penis. The penis sheath is provided with longitudinal chitinous thickenings arranged in zigzag fashion, but there is no armature of spines. The whole is enclosed in a smooth



Text-fig. 12.—*Hexabranchus sanguineus.* Scheme of reproductive system.

sheath. The female duct has rather small albumen and mucus glands and is connected with a spermatheca and spermatocyst, the former with one duct. The usual three apertures into the genital pore are present, viz. male, female and vaginal apertures.

The nervous system (Text-fig. 11) is highly concentrated. A large nerve mass surrounding the œsophagus consists of the cerebral, pleural (pleuro-visceral), pedal and outlying olfactory ganglia, but there is no delimitation of the ganglia, except that it is evident that the cerebral portion is the smallest and the pedal portion the largest. There are sessile eyes on the cerebral ganglia and sessile otocysts on the pedal ganglia. The nerve-cells are so large that the ganglionic mass has a granular appearance to the naked eye. This is characteristic of the genus.

Bergh enumerates five species of *Hexabranchus*, which, though varying in size and colour, have no distinguishable anatomical differences. It is probable, as Eliot suggests, that several at least of Bergh's species are merely colour varieties, for which the old name *H. sanguineus* is most suitable. The above specimen resembles in its coloration *H. faustus* of Bergh (taf. 41, fig. 3).

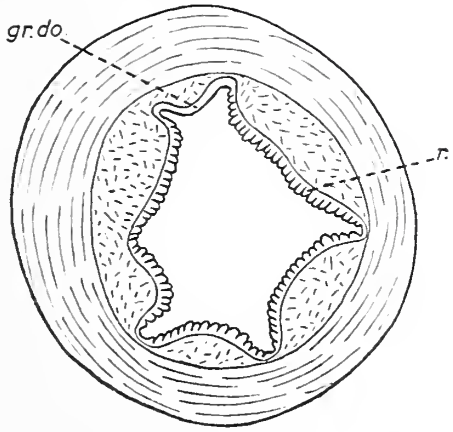
Nembrotha lineolata Bergh. (Text-figs. 13–16; Pl. I, fig. 6.)

Nembrotha lineolata, Bergh, Siboga Report, 1905, p. 199; Eliot, 1906*a*, p. 669.

OCCURRENCE.—Sta. 45, Indian Ocean, near Kuria Muria Islands, 29.x.33, 40 metres; one specimen. 22 mm. long, 5 mm. wide, 10 mm. high at about the middle of the body.

DISTRIBUTION.—Indo-Pacific area.

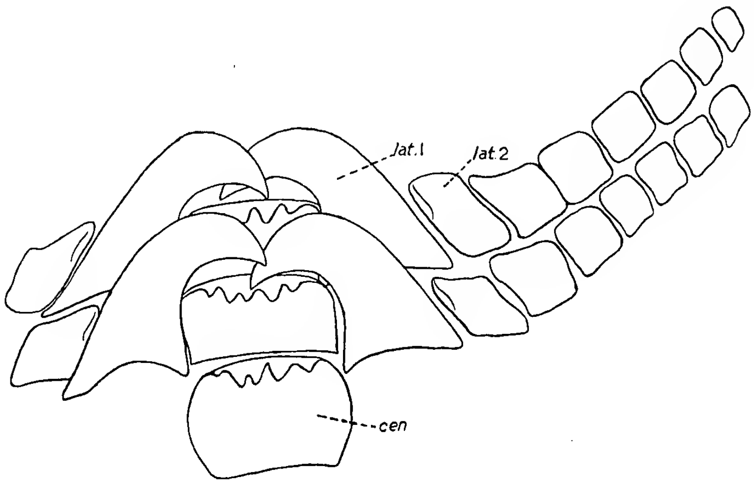
DESCRIPTIVE NOTES.—The specimen is slug-like, with its greatest height in the region of the branchiæ. Its general form resembles that of an *Elysia* rather than that of a member of the Polyceridæ. The head is small, with a narrow mouth aperture overhung by a pair of short puckered oral tentacles, linked together so as to form a kind of oral veil. On the summit of the head lie the pair of relatively large foliate rhinophores, each partly covered by a prepuce-like sheath of unpigmented skin, giving the animal a bespectacled appearance. The mantle is soft, loose and smooth, and since it is continuous with



TEXT-FIG. 13.—*Nembrotha lineolata*. Transverse section of the buccal region to show rods. × 112.

the pedal margin there is no mantle rim. About the middle of the body it rises to the elevation bearing the anus and branchiæ; posterior to this it narrows, with the foot, to form a tail. The anus is mid-dorsal, the genital aperture on the right side just behind the head. The foot is elongated, and in the specimen the lateral margins are approximated. Anteriorly it is truncated, with the corners somewhat prolonged. The branchiæ consist of three ramified stems, but as they have been badly damaged it is impossible to determine their shape. They form a crescent whose opening is posterior, and within the horns of the crescent lies the median anus. The ground-colour of the animal was probably yellow, but is now dirty white, with longitudinal stripes of brown and grey. The stripes do not branch, and rarely unite. They run parallel with one another, and if three stripes converge towards a narrower part of the body, the middle stripe fades out, as in the head and tail regions. A median stripe runs along the back and stops short anteriorly between the rhinophores, while the second lateral stripe is continued forwards ventral to the rhinophores as a broad band, which joins its fellow round the front of the head between the top of the head and the oral lobes. Posteriorly the three middle stripes ascend the branchial stems and fade out at the base of the filaments, commencing again posterior to the branchial region, while the lower stripes are continuous round the base of this area. Posteriorly the main stripes extend to the tail end. There are no spots or interrupted lines on the body. The oral region and foot are of a faded Prussian blue colour, and the same colour tinges the three groups of branchiæ.

The mouth aperture, which is small and unguarded by jaws, leads by an introvert to the small buccal mass. The introvert is coloured a deep blue and is muscular, but not thick-walled; its lateral borders are almost parallel. A pair of short, branched retractor muscle tendons pass backwards and lateralwards to the body wall. The posterior part of this region forms the buccal mass proper. *Externally* the difference is marked by a change of colour from blue to yellow, and the odontophore shows through its wall as a pair of rounded masses, each with its own branched retractor muscle. *Internally* the limit between introvert and buccal mass is shown by a sudden constriction of the wide cavity, the entrance appearing brown in colour. On removing and mounting this region, the brown colour was seen to be due to a collar (Text-fig. 13) made up of several rows of chitinous rods,



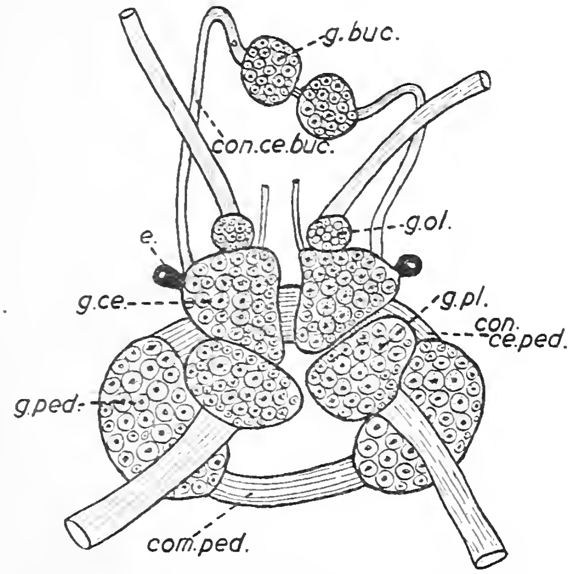
TEXT-FIG. 14.—*Nembrotha lineolata.* Three centrals and part of two rows of lateral teeth. × 200.

similar to the rod cells of the jaws of many Nudibranchs, but less compactly arranged. The collar is broken mid-dorsally. The radula is very small and narrow, and lies on the usual pulley-shaped rotella. It consists of 14 rows of teeth, the maximum number of teeth in any row giving the formula 7.1.1.1.7 (Text-fig. 14). Bergh ('Siboga Reports', 1905, p. 199) described 32–36 rows of teeth in this species. The rachidian tooth lies in a deep groove between the large and strong first laterals, which overlap it. It is colourless and can be of little use, and it is not surprising that in the allied genus *Trevelyana* the central is absent. Its shape is hemispherical, the free edge being slightly recurved, with four blunt denticles, of which the second on one side is bifid, giving a slight asymmetry to the tooth. The first lateral is very large and strongly hooked, with a pointed process on the narrow concave base, so that its shape is somewhat like that of a Cestode hook. The second lateral is trapezoidal, with a slightly elevated cutting edge, but neither cusp nor denticles. The remaining laterals are mere flat tiles on the radular ribbon. They diminish both in size and chitinization as their distance from the rachidian tooth increases.

No salivary glands were found. The œsophagus is thin-walled and passes straight backwards to the visceral mass, which exhibits only hermaphrodite gland on its surface. The liver and stomach are in the centre of the mass, into which the œsophagus plunges.

The stomach is small and receives the bile ducts. From its left border comes off the intestine, which curves forwards, loops round the heart, and passes back along the right side, finally turning dorsalwards to the median anus.

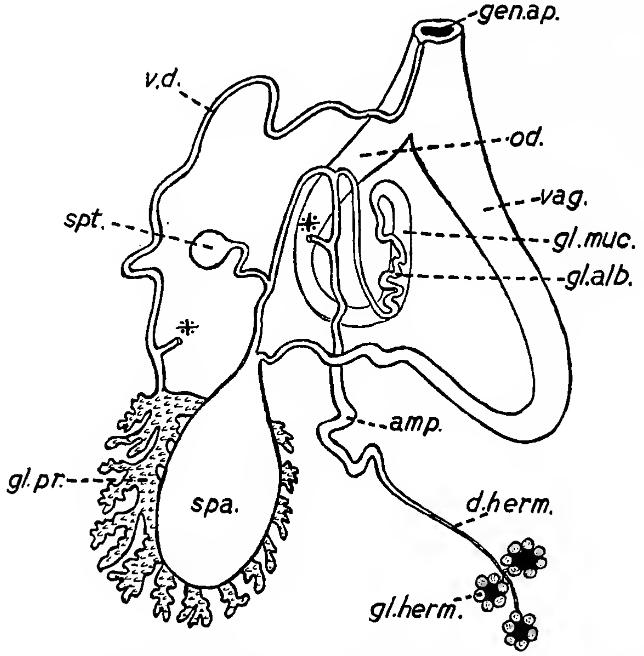
In a single specimen it is difficult to make out all the details of the reproductive system, though the chief portions could be dissected (Text-fig. 16). The hermaphrodite gland forms the rind of the compact ovate visceral mass. The surface is studded with small rosette-shaped areas (*gl. herm.*) composed of a central circular ductule surrounded by from 5–7 smaller, rounded germinal diverticula. The slender common hermaphrodite duct (*d. herm.*) leaves the gland on its right side and passes forwards to the accessory genital complex, which is nearly two-thirds the size of the visceral mass. On entering this region the duct enlarges, forming the ampulla of the hermaphrodite duct (*amp.*).



TEXT-FIG. 15.—*Nembrotha lineolata.* Nervous system, dorsal view. × 33.

It then contracts again, separates into male and female portions, the latter dividing at right angles into oviducal and vaginal ducts. The oviduct becomes very much thickened and convoluted. It is at first opaque (albumen gland), then translucent (mucus gland), The walls become muscular as the genital aperture is approached. The vaginal duct turns posteriorly and bears two diverticula. The one nearest to the vaginal aperture is a pear-shaped thin-walled vesicle, the spermatheca (*spa.*), which contains a mass of debris. The other is borne on a short stalk, is spherical and thicker walled and is called the spermatocyst (*spt.*). Wrapped round the spermatheca is a racemose prostate gland (*gl. pr.*), whose duct joins the male duct to form the long coiled vas deferens, which is thick-walled and opens into the common genital atrium. Thiele states that there is no prostate in *Nembrotha*, but this species has a very well-developed one. No penis was present in the specimen, and the details of this part of the apparatus could not therefore be investigated.

The concentrated ganglionic mass surrounding the œsophagus is composed of a pair of triangular compressed cerebral ganglia, ovate pleural (pleurovisceral) and elongated pedal ganglia, the last named being the largest (Text-fig. 15). The cerebro-pleural and cerebro-pedal connectives are very short, but the pedal commissures are longer owing to the lateral position of these ganglia. Two small olfactory ganglia (*g. ol.*) lie on the anterior face of the cerebral ganglia, and laterally are the small, pigmented and shortly stalked eyes. The buccal ganglia (*g. buc.*) are linked with the cerebrals by means of long connectives ; their commissure, on the other hand, is unusually short. From the pleural ganglia a pair of long broad nerves pass backwards to the branchial region and are connected by a ganglionated cord anterior to the anus.



TEXT-FIG. 16.—*Nembrotha lineolata.* Scheme of reproductive system. The male duct should be continuous between the asterisks.

Glossodoris sp.

OCCURRENCE.—Sta. 45, South Arabian coast, near Kuria Muria Islands, 29.x.33, 40 metres ; one specimen, 13 mm. long, 5 mm. broad. Note 134 states that the specimen was found, with another Dorid, upon or within a large fleshy, much-branched Alcyonacean.

DESCRIPTIVE NOTES.—This specimen has no external surface, except in small areas. The mantle and foot had been stripped off, leaving the rhinophores and branchiæ. The former are of the usual perfoliate type, the latter consist of eleven, small, simply pinnate gills. The buccal mass is large and protruded.

The inner mouth lining is protected by a broad girdle of lip rods, 2 mm. deep. The rods are very regularly arranged in rows, and each of the functional rods is bifid and curved like a radular tooth. The radula is relatively as small as the lip plates are large. It consists of 54 rows, the maximum number of teeth in a row being 46.0.46. There is no central. The first lateral has a single denticle on its mesial face and three denticles laterally. The remainder of the teeth have denticles on their outer edges only, usually from 4–7. The cusp increases slightly in length up to approximately the 12th tooth in the row, then decreases again, the denticles, however, getting longer. The outermost teeth are smaller but not degraded. Owing to the shortening of the cusp and lengthening of the denticles of these outermost teeth they resemble combs or even forks in some of the rows. The stomach is indistinct and there is a small gall bladder.

The central nervous system shows small cerebral ganglia, widely spaced eyes, large pleural (pleurovisceral) ganglia and rather large ovate pedal ganglia. No outlying olfactory ganglia are visible, but poor preservation may explain this.

In any collection of Nudibranchs from the Indo-Pacific area, it is to be expected that a genus so rich in species as *Glossodoris* would be represented, and it was disappointing to find only one imperfect specimen. The number and simplicity of the branchiæ, the elongated shape, the lip plates of forked rods, and the radula with denticulate lateral teeth but no rachidian tooth are sufficiently diagnostic of the genus *Glossodoris*, but owing to the absence of the outer skin and foot, and the bad preservation of the internal parts, particularly of the genitalia, it is impossible to determine the species.

A Dorid.

Occurrence.—Sta. 45, South Arabian coast, near Kuria Muria Islands, 29.x.33, 40 metres. The specimen is 7 mm. long, 6 mm. broad and 4 mm. high. The foot is 5 mm. × 3 mm.

Descriptive Notes.—The specimen was found upon or within a large fleshy much-branched Alcyonacean.

There is no colour, and the warts of the notum are eroded so that it is difficult to be certain of the appearance of the living animal. The body is soft, broad and plump, much flattened ventrally, of fairly regular elliptical outline. The rhinophores are widely spaced, their sheaths with smooth rims. The branchial pocket is torn, but the edge was probably thrown into folds. The branchiæ are rather large, 5 in number, set very far back on the body, tripinnate. The foot is very broad and flat, not puckered at the edges, broadest anteriorly, with rounded anterior margin, and not, as far as could be seen, bifid. Posteriorly it tapers somewhat, but is rounded and does not project beyond the mantle skirt. The latter is 2 mm. wide on each side. A pair of round oral tentacles curve backwards and lateralwards like ram's horns on the side of the small head.

The interior was too much decomposed to allow of detailed investigation of the organs. The buccal mass is very large and the salivary glands large, irregular, and bent back on themselves. The stomach is well defined and there is a small gall bladder. The whole of the liver and hermaphrodite gland had broken up into small pieces.

The lips have a chitinous cuticle but no lip plates. The radula has 26 rows of teeth, with a maximum formula of 36.0.36. The innermost laterals are not particularly small or sunk, as in some genera, nor do they disappear in the older rows. There is a slight but gradual increase in size in the teeth up to about the 30th tooth in the row, then a small decrease, and the last four or five teeth are degraded, with fringed edges. The functional teeth are simply hooked, are set on narrow bases, but have a hump on the back of the tooth where the cusp arises from the base.

The reproductive system could not be fully investigated. The female duct has the usual albumen and mucus glands, and is unarmed. No prostate was found and no armature on the male duct. A large spermatheca and pear-shaped spermatocyst are present.

The nervous system is small, flattened and concentrated, though the component ganglia are distinct. It resembles that of *Discodoris*. Olfactory ganglia are present and the eyes are widely spaced. The pedal ganglia are lateral and the pedal commissure is short.

The specimen may be a species of *Trippa*, but the small size, bad preservation and absence of the lower portion of the genital duct make identification difficult.

Discodoris sp.

Cf. Bergh, S.R., 1876–8, p. 519 ; 1884–92, p. 897 ; Eliot, 1903*b*, p. 364.

Occurrence.—Sta. MB II (*c*), South Arabian coast, 28.x.33, 30 metres; one specimen, 7 mm. long, 4·5 mm. broad, 3 mm. high.

Descriptive Notes.—The body is broadly ovate, slightly broader anteriorly. The notum is covered all over with small papillæ like down. There are remains of a few spots laterally and the branchiæ are dull brown, otherwise the specimen is colourless. The skin is loaded with rod-like spicules. The rhinophores are retracted into cups, whose rims, flush with the surface, are papillose. The branchial aperture is similar, and there are six branchiæ, contracted but not withdrawn into the cup. The head is retracted into a kind of nuchal pocket under the mantle, and bears a pair of small finger-like tentacles. The mantle skirt is 1·5 mm. wide, the foot long and narrow, projecting posteriorly beyond the mantle as a tail. It is 5 mm. long and 1 mm. wide, its anterior border bifid.

The lips appeared to be unarmed, but on mounting the skin lining the anterior portion of the cavity of the buccal mass a pair of small irregular jaw plates were found, whose rodlets are short, compact and blunt. The radula consists of 42 rows, with a maximum formula of about 63.0.63, but the teeth are so small and close together that it is difficult to count them. There is no rachidian tooth. All the laterals are hooked and have smooth edges. The innermost are broad and shortly hooked, the outermost very long and slender, and hardly hooked at all but merely curved slightly. The remainder of the gut was badly preserved.

There is no armature on the genital apparatus. It is impossible to determine the species of this single and very small specimen. It agrees fairly closely with Bergh's *D. boholiensis* in the number of rows in the radula, the number of teeth in a row and in the attenuated nature of the lateralmost teeth.

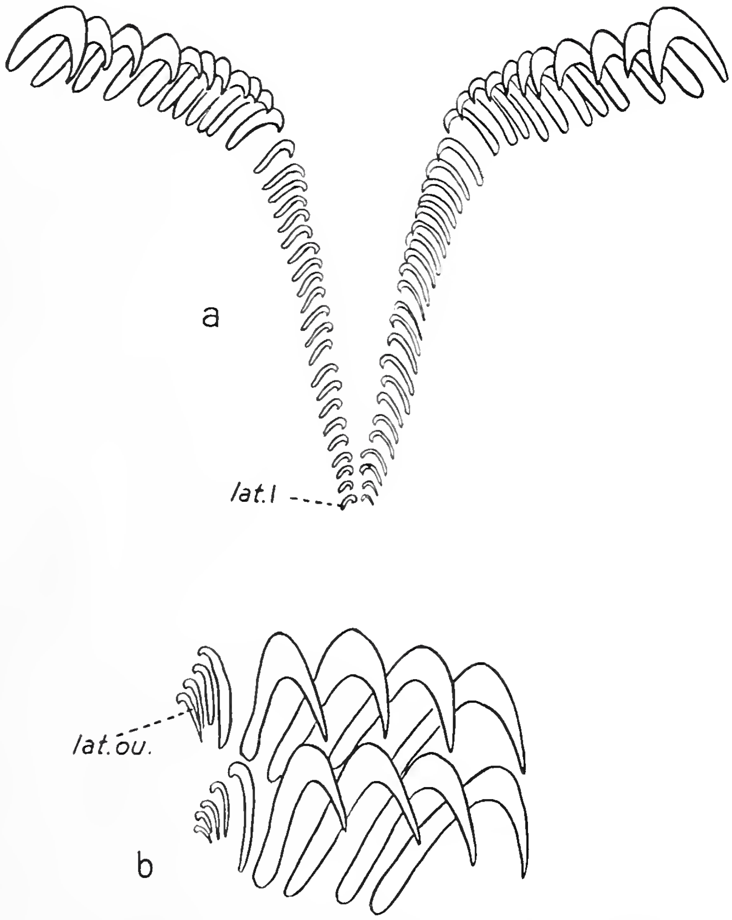
Halgerda willeyi Eliot. (Text-figs. 17, 18 ; Pl. I, fig. 3.)

Halgerda willeyi, Eliot, 1903*b*, p. 372, pl. xxxii, fig. 5 ; Vayssière, 1912, p. 40, pl. i, fig. 7.

Occurrence.—Sta. 45, South Arabian coast, near Kuria Muria Islands, 29.x.33, 40 metres ; one specimen, 20 mm. long, 14 mm. broad, 10 mm. high ; foot 15 mm. long, 3 mm. broad.

Distribution.—Red Sea and Indian Ocean.

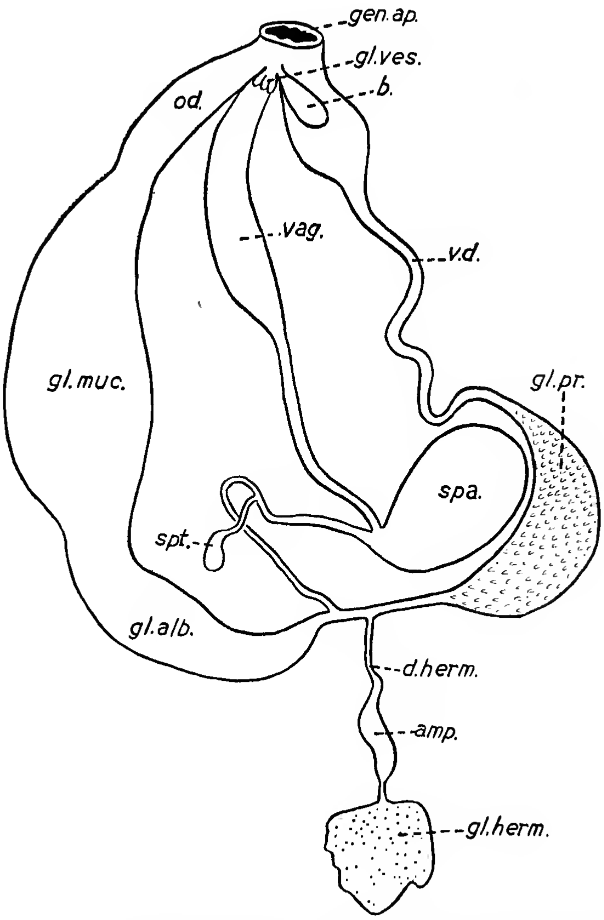
Descriptive Notes.—Only black and white colouring is present, the yellow mentioned by Vayssière having left no trace. The shape is broadly ovate, the mantle skirt projecting well beyond the foot on all sides. The notum has black streak-like markings. Some of these are branched and run at right angles to the mantle edge. Others, rarely branched, are longitudinal and run along the middle of the back. Tubercles are present and there is a dorsal keel. The anterior tubercles are median; the posterior ones form a circlet around the branchial region, but some distance from it. The tubercles are connected by ridges which give the appearance of a reticulum. The markings on the mantle edge are visible on its underside and the edge of the foot has a similar pattern. There are only two bunches of gills, much branched and striped with black. The anus projects on a tube with crenated aperture between the gills. The head bears very small button-like oral tentacles, and completely retracted, lamellate rhinophores. The mouth aperture is circular, corrugated owing to folds, and marked with black spots. The anterior



TEXT-FIG. 17.—*Halgerda willeyi.* *a*, Inner lateral teeth to show median groove in the row. × 54. *b*, Outermost laterals. × 126.

margin of the foot has two lips. The skin of the notum is soft except on the tubercles, but no spicules were found.

The buccal mass is without jaws, though there is a thin, pale, smooth chitinous lining to its anterior portion. The radula (Text-fig. 17) is well developed, and measures 8 mm. long and 4 mm. wide in the functional portion. The radular sac protrudes from the ventral side of the buccal mass as a rounded knob. There are 50 rows of brown teeth, with a maximum formula of 52.0.52. The ribbon appears narrow, but when extracted is found to be of considerable width owing to the depth of the central groove (Text-fig. 17*a*), and to the curvature downwards of the outer edges. Since the teeth in the groove and on the recurved edge are much paler than those on the flattened part of the radula, it is reasonable to assume that the dark brown teeth of the flattened area are those most used. There is no central. The first 20 laterals of each side in one of the broadest rows lie within the groove; then come about 28 teeth on the flattened cutting surface, and the last three or four teeth in the row are on the recurved portion of the ribbon. The teeth of the first group are small but well developed, with short, distinct, smooth cusps curved towards the centre. Their bases are narrow and rather shapeless. Although the cusps get longer, stronger and more deeply coloured as the distance from the centre increases, there is



Text-fig. 18.—*Halgerda willeyi*. Scheme of reproductive apparatus.

nevertheless an abrupt change between the 20th and 21st tooth, *i. e.* at the point where the groove becomes flattened out. The cusps remain simple, but the bases become stronger and more and more oblique. Finally the outermost three or four teeth (Text-fig. 17*b*) show decreasingly smaller bases and cusps, and remind one of the vestigial marginal teeth of a *Patella*. It is characteristic of the teeth in *Halgerda* that the whole of the base curves over into the cusp, and that there is no shoulder or prolongation of the base anterior to the cusp (cf. *Asteronotus*, p. 104).

The hermaphrodite gland lies on the liver (see Text-fig. 18). Its duct has an ampulla (*amp.*), and divides into male and female portions. The vas deferens (*v. d.*) passes through a large prostate (*gl. pr.*), which is wrapped round the spermatheca (*spa.*). The narrowed sinuous portion of the duct becomes greatly enlarged near the male aperture, and this region is provided with a muscular bulb (*b.*). No stylet could be found. The female duct receives a fertilizing duct from the seminal receptacles, and then enlarges as it passes through albumen and mucus glands, which are entwined to form the usual accessory genital complex. The female aperture is large and muscular. The third aperture into the genital atrium, that of the vagina (*vag.*), leads direct to a large pear-shaped spermatheca, whose second duct is connected with a globular spermatocyst communicating with the fertilization chamber by a slender duct. Bean-shaped vestibular glands (*gl. ves.*) encircle the vaginal aperture. The important points for classificatory purposes are the presence of a well-defined prostate, the bulb on the unarmed penis and two ducts to the spermatheca.

Halgerda apiculata (Alder & Hancock).

Doris apiculata, Alder & Hancock, 1864, p. 122, pl. xxx, fig. 8.
Halgerda punctata, Farran, 1905, p. 339.
Halgerda apiculata, Eliot, 1906*a*, p. 1002 ; Vayssière, 1912, p. 38 ; O'Donoghue, 1932, p. 155.

Occurrence.—Sta. 10, Red Sea near Perim, 17.ix.33, 55 metres ; one specimen, 30 mm. long, 23 mm. broad, 11 mm. high. Foot 20 mm. long, 3·5 mm. broad.

Distribution.—Red Sea and Indian Ocean.

Descriptive Notes.—There is no trace of colour. The notum is strongly tuberculate, with keeled elevations between the smoothly rounded tubercles and soft smooth areas between the keels. There is a strong mesial keel commencing 4 mm. from the anterior end and ascending over the dome-shaped back, stopping short and bifurcating in front of the branchial cup. Lateral elevations cut off two pairs of areas enclosed by tubercles on the summit of the back, and there are imperfect ones anterior and posterior to them. From these four completely or partially enclosed areas rows of smaller tubercles run out towards the thin smooth edge of the mantle skirt. Here the tubercles are closer together, smaller and not always linked by keels. Other radiating rows of tubercles fill up the gaps between the main lines. No trace of rhinophores could be found externally, so completely were they retracted. The branchial cup is also strongly contracted and stands up like a spout in the middle line posteriorly, so that it looks like one of the tubercles. On slitting it up, however, it is seen to lead to an expanded chamber bearing on its floor a pair of contracted black-spotted branchiæ, each branched into three. Between the branchiæ lies the anus, on the summit of a tube whose border is crenated. The lining of the cup is also pigmented in the form of spots. The foot is extremely narrow, even allowing for its contraction. Anteriorly it has a bifid border, cleft mesially. Posteriorly it is prolonged into a tail. The head is very small, and is completely hidden under the forward projection of the mantle slit. In the specimen it is shut in by an ogee-shaped fold which fades out on either side of the foot. The mouth is hidden and is very small. The foot projects forwards, thus pushing aside the small, simple, oral tentacles, which are here contracted to mere knobs.

Internally the connective tissue covering the dorsal body organs is pigmented, but there is no pigment ventrally. The buccal mass is well developed, with strong tendons mooring it to the sides of the body wall. A flat chitinous plate, without rod cells, lies at the entrance to that portion of the buccal mass containing the odontophore. The radula has 55 rows, with a maximum formula of 65.0.65. The general arrangement is similar to that described in *H. willeyi* (*vide supra*, p. 101), but there is a more gradual change between the functional teeth on the flat part of the ribbon and those lying in the central groove. The latter slope sideways and mesialwards; the former are almost vertical, the cusps of one row usually alternating with and overlapping those of the next row. The last four or five teeth in a row are smaller, curve inwards and tend to become split and degenerate, but they can hardly be described as denticulate. The œsophagus is short, passes to the left, and leads to a thin-walled stomach cavity, containing white amorphous matter. It receives a single bile duct ventrally. The intestine leaves on the right side, close to the entrance of the œsophagus, so that the stomach has a blind posterior end. The intestine curves backwards on the right side towards the anus. No salivary glands could be found in the specimen; Bergh describes them as long and thin, no thicker than nerves, in an allied species.

The reproductive organs are similar to those of *H. willeyi*, but the ducts are much shorter. The penis bulb is pigmented, but not armed.

Asteronotus hemprichii Ehrenberg. (Text-figs. 19, 20.)

Asteronotus hemprichii, Ehrenberg, 1831, p. 97; Bergh, 1877, pp. 161–173; Eliot, 1903*b*, p. 384, pl. xxxiv, figs. 5, 6; *id.*, 1908, p. 116.

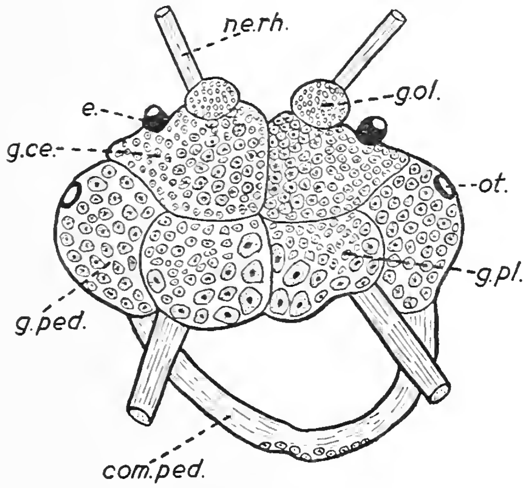
Occurrence.—Sta. 27, Gulf of Aden, near Cape Guardafui, 12.x.33, 26–91 metres; one specimen, 32 mm. long, 23 mm. broad, 10 mm. high.

Distribution.—Indian and Pacific Oceans.

Descriptive Notes.—Without colour except for a few brown spots. The notum is very broad, giving an ovate outline. It overhangs the head and foot, is broadest posteriorly and tapers to a point anteriorly. The dorsal surface is covered all over with papillæ, with radiating and anastomozing areas formed by raised ridges, bearing a few knob-like excrescences. It is full of spicules. The mantle skirt is very wide and thin, extending 10 mm. beyond the foot on all sides except anteriorly. Its underside is spotted with brown and covered with a fibrous-looking radiating pattern. The rhinophores are completely retractile into cups with lobed edges, the right aperture having nine lobes. The branchial region is also much contracted, with a small, eight-lobed aperture leading to the gill chamber. There appear to be seven gill plumes united by webbing, but owing to contraction, it is difficult to be certain of this. The foot is only 19 mm. long and 5 mm. wide, much contracted and puckered along the edge. The anterior margin is two-lipped, the anterior lip cleft mesially. The head is very small, with a pair of oral tentacles contracted to small lateral knobs.

The lining of the small mouth aperture is thrown into numerous folds. The anterior portion of the buccal mass was evidently capable of considerable extension, as it is folded both longitudinally and transversely, and is supplied with from 6–8 strong flat tendons. There is no trace of mouth armature. The radular sac projects ventro-laterally from the buccal mass towards the left, the right side being occupied by the genital complex. The radula has 45 rows, with a maximum formula of 53.0.53. The first row has ten teeth on one side and fourteen on the other. All the teeth are simply hooked. The last three or four teeth in a row are small and degenerate. It is characteristic of the teeth that the base projects forwards as a kind of hook or shoulder, so that the cusp is not terminal on the base. A pair of short, stout, recurved salivary glands lie on either side of the œsophageal region on the dorsal side of the buccal mass, their ducts opening in the usual position. The œsophagus is short, and runs along the mid-ventral side of the lenticular stomach. The duct of the digestive gland is very large and is provided with a small globular gall bladder. Like the œsophagus, it is connected with the ventral wall of the stomach. The intestine leaves dorsally and from the right side, curves lateralwards and then posteriorly to ascend to the anus.

The hermaphrodite gland is embedded in the liver on its dorsal side. The duct is at first slender, then enlarges to form an ampulla, and contracts again suddenly before splitting into male and female portions (see Text-fig. 20). The male duct at once enlarges to form a prostatic enlargement, which is partly creamy white and partly vesicular and surrounds the spermatheca. The vas deferens, at first sinuous, finally runs straight towards the male aperture; it is unarmed. The female duct is provided with a much convoluted albumen and simple mucus gland. The vagina, which is long, has vaginal



TEXT-FIG. 19.—*Asteronotus hemprichii.* Nervous system, dorsal view. × 36.

glands near its aperture and is no wider than the vas deferens. It is connected with a large globular spermatheca, and, by a separate duct, with the fertilization chamber. The latter duct has a stalked pear-shaped spermatocyst opening into it. No trace of a stylet gland or stylet could be found, though Bergh described these. It is quite common for the genital atrium to be damaged in Nudibranchs, and with only one small specimen at my disposal, no means of verifying Bergh's statement are possible.

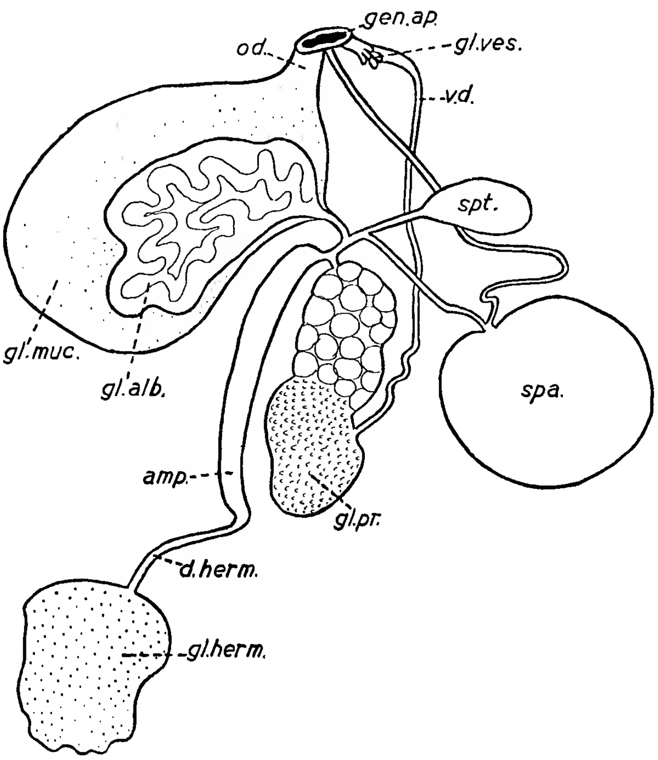
In the nerve ring (Text-fig. 19) the ganglia are contiguous, but their outlines are distinct. The eyes are sessile and there are large olfactory ganglia. The pedal commissure is very broad.

Asteronotus sp.

Cf. Asteronotus madrasensis, O'Donoghue, 1932, p. 158.

OCCURRENCE.—Sta. 43. South Arabian Coast, near Kuria Muria Islands, 28.x.33, 83 metres; one specimen, immature, 16 mm. long, 14 mm. broad, 6 mm. high.

DESCRIPTIVE NOTES.—Buff coloured, with very irregular brown markings and blotches, largest laterally, the central part of the notum being almost clear. There are a few brown blotches on the underside of the mantle, but none on the foot. The general form is ovate, with a somewhat frilled edge to the mantle. The body is soft but firm, rather high in the middle. It is covered with fine short papillæ and is marked by a radiating network both above and below. The mantle skirt is very wide, being 6 mm. laterally, but a little less anteriorly and posteriorly. The foot is narrow, and measures 11 mm. in length and only 4 mm. in breadth. Its anterior margin is bifid, the front lip split in the middle line. A short tail is present but is not visible dorsally. The lateral border of the foot is puckered, indicating that it is much contracted. The oral tentacles are short and tapering, the rhinophores completely retracted, with a toothed sheath margin. The branchiæ are partly retracted within the transversely ovate aperture, and consist of six much branched structures spotted with brown. The two anterior branchiæ are larger than the others.



TEXT-FIG. 20.—*Asteronotus hemprichii.* Scheme of reproductive apparatus.

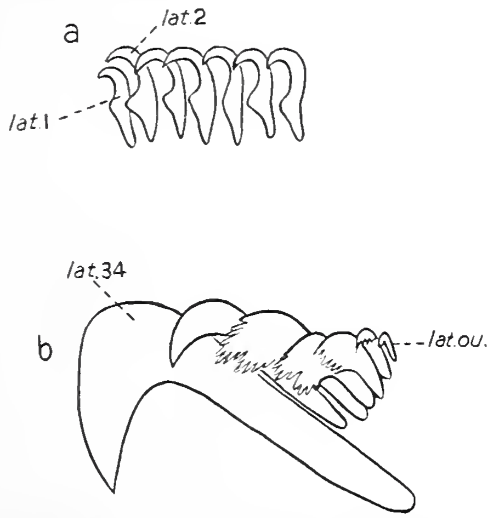
The buccal mass is well developed. There is no mouth armature. The radula consists of 56 rows, with a maximum formula of 72.0.72. The teeth bear simple hooks, and there is a projection or shoulder on the base, so that the cusp is not terminal, and the shoulder lies on the convex side of the tooth. At the end of each row are three or four degenerate teeth, much smaller than the rest. On the whole the teeth resemble those of *A. hemprichii* but are more numerous. A pair of thin salivary glands open into the buccal cavity in the usual position. The œsophagus expands into a stomach situated on the left side of the body, and outside the liver. A large bile duct enters the right side of the stomach. The intestine leaves posteriorly, bends to the left, then forwards and to the right, crossing the middle line dorsally. The rectum passes down the right side and ascends to the mid-dorsal anus.

The genital complex is immature and appears to resemble that of *A. hemprichii.* A similar division of the prostate into two parts occurs. The nervous system is also like that of *A. hemprichii*, *i. e.* it shows contiguity but not fusion of the three pairs of ganglia, and the commissures and connectives are not distinguishable. There are similarities between this specimen and O'Donoghue's *A. madrasensis*, but owing to its small size and immaturity no attempt has been made to give it a specific name.

Artachæa intermedia sp. nov. (Text-figs. 21–23 ; Pl. I, fig. 1.)

Occurrence.—Sta. 27, Gulf of Aden, 12.x.33, 30–70 metres ; two specimens, one much darker than the other, the larger 27 mm. long, 20 mm. wide and 8 mm. high (see Pl. I, fig. 1 *a* and *b*). The contracted foot measures 14 mm. long and 2 mm. broad.

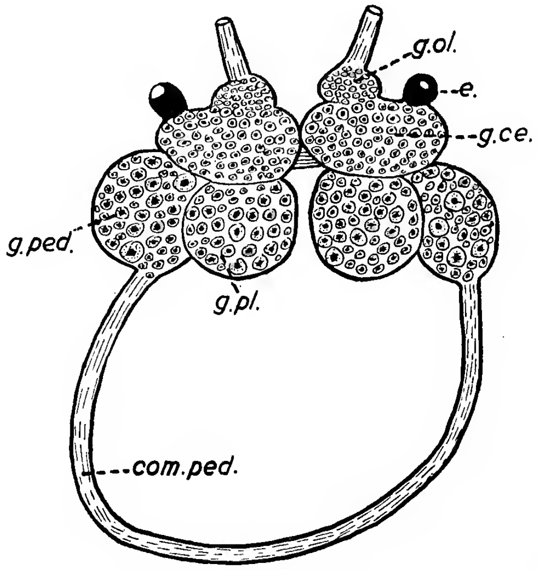
Descriptive Notes.—The animal is fairly soft, and of broad, elliptical shape, with very small rhinophores and branchiæ. The notum is dark brown and mottled, but not definitely spotted, and is covered with scattered warts of varying sizes, but all small.



Text-fig. 21.—*Artachæa intermedia.* *a*, Seven inner lateral radular teeth. × 270. *b*, Seven outermost laterals. × 270.

The warts are centres of radiating star-like patterns, and are obviously much flattened. In the lighter specimen some of the warts have orange-coloured filamentous tags projecting from them, as though the warts were merely the bases for softer papillæ. The edge of the notum has fine warts, which give it a corrugated appearance. The mid-dorsal warts form a faintly marked keel. One specimen is flat, but the other is rolled up almost into a ball. The rhinophore sheaths have papillose rims and are so greatly contracted that they appear no larger than the warts. The branchial aperture is also very small and is papillose. The branchial chamber has six tripinnate, much-branched gills. The mantle has a very broad overhang of nearly 10 mm. laterally, and 4 mm. anteriorly and posteriorly. The foot is therefore very narrow, being barely 2 mm. wide in one specimen, although obviously in a much contracted condition. Anteriorly the foot shows a puckered bifid border and completely hides the mouth aperture. Posteriorly there is a short tail free from the body, but not visible dorsally. The ventral side of the mantle is spotted irregularly with dark brown blotches ; it is quite smooth, but shows the star-like pattern of the notum. A few of the smaller spots extend to the edges of the foot. The head bears a pair of small, flat, oral tentacles.

There is a chitinous mouth lining but no buccal armature. There are 34 tooth rows, with a maximum formula of 40.0.40 (see Text-fig. 21). The radula resembles that of *Halgerda* in the shape of the tooth rows, *i. e.* the functional part of the radula is not the central part, since the latter is sunk in a groove. This central part bears small lateral teeth, the two halves of a row being bent backwards in a V-shape. In older parts of the radula some of these teeth disappear, leaving a naked area. The teeth increase gradually in size towards the edge of the sunk area; then an abrupt enlargement occurs on the flat portion of the radula. Here again the increase in size is gradual, the largest tooth being the 34th lateral (Text-fig. 21*b*). The 35th tooth is smaller but similar, while the last five teeth in the row are close together and vestigial, with fringed edges and a short cusp. All the teeth except the degraded ones are simply hooked. Many have an expansion of the base on the *concave* side of the tooth, like the guard on the hook of a tapeworm, but this disappears on the larger teeth, whose bases are long and narrow.



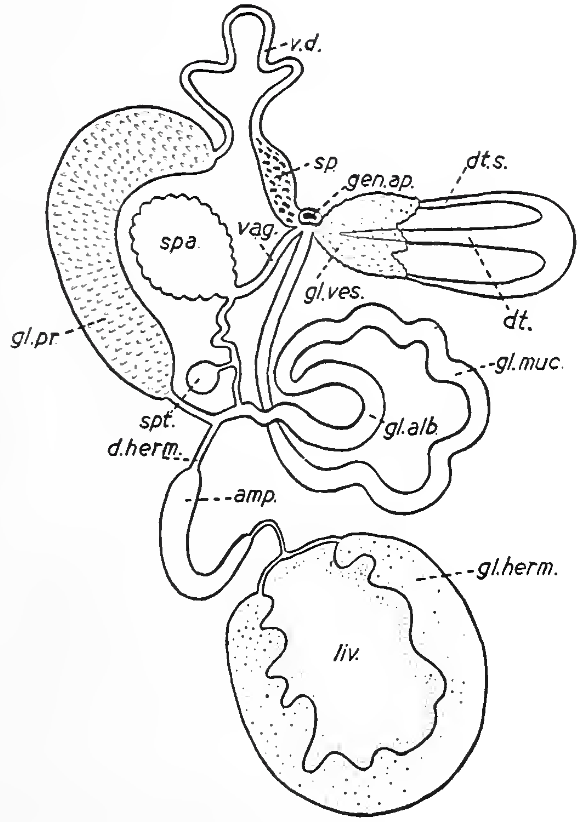
Text-fig. 22.—*Artachœa intermedia.* Nervous system, dorsal view. × 22.

The gut has an enlarged œsophagus with thin walls; the stomach is small and is embedded in the liver. There is a gall gladder. The liver is entirely hidden in dorsal view by a thin layer of gonad. Ventrally the gonad forms a peripheral strip, the centre only being occupied by liver tissue. The intestine leaves the right side of the stomach as usual and passes straight backwards to the dorsal anus.

The hermaphrodite gland occupies, as above stated, the whole of the dorsal and the peripheral portion of the ventral side of the visceral mass (Text-fig. 23). A pair of ducts unite at right angles to form the hermaphrodite duct, which enlarges to form an ampulla bent in a U shape. After contracting again this duct divides into two, a male and female portion respectively. The male portion passes through a large creamy white prostate, which is wrapped round the spermatheca. The sinuous vas deferens (*v. d.*) passes into an armed penis (*sp.*) in one of the specimens, but in the other this armature could not be found. There are numerous rows of curved hooks. The female duct is short, and has the usual albumen and mucus glands along its course. The vagina was unfortunately torn in one specimen, but its opening into the genital atrium had an irregular gland (*gl. ves.*) close to it, surrounding a club-shaped muscular dart sac (*dt. s.*) containing a flexible horny dart. Spermatheca and spermatocyst are present. The nervous system (Text-fig. 22) exhibits contiguity but not confluence of the ganglia of the nerve ring. The olfactory ganglia are relatively large, and the pedal commissure is longer than in most Dorids.

The two specimens agree in their anatomy and probably belong to the same species. They differ, however, from the recorded species of *Artachœa*, of which those known to me are :

A. rubida Bergh (1880–81, p. 231).
A. clavata Eliot (1907, p. 81, and 1908, p. 116).
A. verrucosa Eliot.



TEXT-FIG. 23.—*Artachœa intermedia.* Scheme of reproductive apparatus.

It is possible, but not likely, that Eliot's second species is a variety of Bergh's *A. rubida.* Its first lateral teeth were denticulate on both sides, and the outermost ten teeth (Nos. 31–40) also bore denticles. There was no trace of labial armature and six small branchiæ were present. Bergh's *A. rubida* had eight branchiæ, a rather broad foot and a radular formula of 31 × 47.0.47, the last four teeth smooth, and from the 13th to the 43rd on each side denticulate along one side. The penis had five longitudinal rows of hooks. He did not mention a prostate on the male duct, but only a soft prostatic portion of the vas deferens. Eliot described *A. clavata* twice. In 1907 he gave a detailed description of a recognizable species from Zanzibar, which he says was hard and harsh to the touch, with eight branchiæ, a weak labial armature and a radula of very numerous denticulate teeth (120–150 laterals). In 1908 he described a specimen from the Red Sea which had chocolate blotches under the mantle and did not resemble the Zanzibar specimen superficially, but was more like Bergh's *Phialodoris podotria* (1890, pl. lxxxv, fig. 5). It had a labial armature and a radular formula of 50.0.50 in 20 rows. He mentioned also the reticulate pattern between the warts and said it had large rhinophores and branchiæ. It is probable that the Zanzibar and Red Sea specimens belonged to different species, but there is not sufficient evidence to show whether the second is the same as that now described from the John Murray Collection. I suspect that it may be, despite the absence of labial armature, which at its best is vestigial in the genus. The present species seems to form a link between *A. rubida* Bergh and *A. clavata* Eliot, and it is proposed to name it *Artachœa intermedia.*

Thus, *A. rubida* has a soft body, eight branchiæ, unarmed lips, a radular formula of 31 × 47.0.47, the last four teeth smooth, the middle teeth of the row denticulate along one side and increasing in size for two-thirds of the row, the penis with five longitudinal rows of hooks.

A. intermedia has a soft body, six branchiæ, unarmed lips, a radular formula of 42 × 40.0.40, teeth smooth, increasing in size up to the last four or five degraded ones, penis with numerous small hooks.

A. clavata has a hard, harsh body, eight or nine branchiæ, lips with weak armature, radular formula of 35 × 150.0.150, the teeth denticulate and increasing in size up to the last two or three degraded ones, the penis armed with thick-set spines.

In addition it may be remarked that *A. intermedia* has a dark brown, mottled notum, covered with scattered warts which are centres of radiating groups of spicules. The rhinophores and branchiæ are small, the mantle skirt broad, flecked with chocolate brown on the underside, and exhibiting a star-shaped pattern similar to that of the notum. Foot narrow, with bifid anterior border and short tail. Two flat oral tentacles. Genitalia as in other species of the genus, viz. male duct with large prostate, vagina unarmed, but having near the aperture a vestibular gland and a dart sac containing a horny dart. Spermatheca with two ducts, and spermatocyst present. Female duct unarmed, with large albumen and mucus glands.

Phyllidiella pustulosa (Cuvier). (Pl. I, fig. 4.)

Phyllidia pustulosa, Cuvier, 1817, Mem. 8.
Phyllidiella pustulosa, Bergh, 1869*a*, pp. 455, 510 ; *id.*, S.R., 1876–8, p. 382 ; Eliot, 1904*c*, p. 283.

Occurrence.—Sta. MB I (*b*), Bay between Great Hanish and Suyul Hanish Islands, Red Sea, 17.ix.33, 29 metres ; one specimen, 20 mm. long, 13 mm. wide.

Distribution.—Indian and Pacific Oceans.

Descriptive Notes.—The specimen had preserved its dense black ground-colour and white tubercles surrounded by a white halo. There is a median row of tubercles with elongated halos along the keel of the back, the halos of the last two tubercles being confluent. Laterally a row of three tubercles occur, and at the sides of the notum the white area surrounding a tubercle runs down the edge and may enclose several smaller tubercles, the effect in this region being of alternate black and white stripes, as if the black colour had run down the sides. Beneath the mantle rim lie the gill lamellæ, which are grey triangular plates regularly and transversely arranged on each side of the body between the mantle and the foot. There are about 80 lamellæ on each side, large ones alternating with smaller lamellæ. The foot is white, with grey sides and a trace of grey on the pedal sole, but otherwise not marked. It is about 16 mm. long and 6 mm. wide. There is no visible trace of rhinophores or anus; in fact, it is hardly possible to detect which is the anterior end of the animal from the dorsal side. The head is small and is almost hidden by the pedal sole, which projects forwards. It bears two short white oral tentacles overhanging the minute oral aperture. The genital aperture breaks the line of gill lamellæ on the right side, lying between the 13th and the 14th lamellæ.

The mouth leads to a frilled buccal mass, without pigment, and devoid of either jaws or radula. It is held in place by a pair of strong retractor muscles diverging towards the mantle posteriorly, and anteriorly by four small strands attached to the mouth aperture. A short, thick-walled and looped œsophagus passes through the nerve ring and bends towards the left side. A constriction occurs, marked by the presence of four small diverticula, just anterior to the nerve ring. Posterior to the ring the œsophagus again enlarges and becomes suddenly thin-walled. It receives numerous ducts from the voluminous compact liver. This thin-walled region represents the stomach. The intestine, also thin-walled, emerges on the dorsal side of the liver and passes straight back to the posterior anus, acquiring a slightly more muscular wall close to the aperture, where there is an offshoot or rectal cæcum.

Unfortunately the penis was not present and it was not possible to determine whether it was armed. The details of the reproductive system could not be investigated owing to imperfect preservation.

The external characters of this species are easy of identification, but internally the differences between allied species are slight. In the absence of hard parts such as jaws and radula, therefore, the soft parts have been used as criteria. Bergh and Eliot (1904) describe *P. pustulosa* as a species with asymmetrical buccal mass (Bergh) and posteriorly pigmented buccal mass (Eliot). It is probable that both characters are variable; the present specimen exhibits neither.

Dermatobranchus striatus v. Hasselt. (Text-fig. 24; Pl. I, fig. 7.)

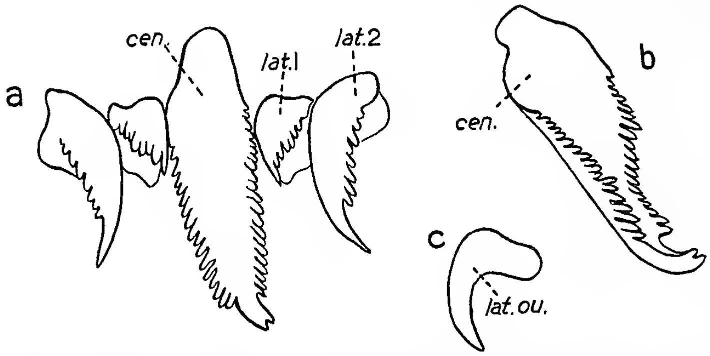
Dermatobranchus striatus, v. Hasselt, 1824, p. 242.
Pleuroleura striata, Bergh, 1905, p. 209; Eliot, 1906*b*, pp. 566–567.

Occurrence.—Sta. 9, Red Sea, near Perim, 17.ix.33, 54 metres; one specimen, 29 mm. long, 9 mm. broad, 5 mm. high.

Distribution.—Red Sea and Indian Ocean.

Descriptive Notes.—The body is more slug-like than in the genus *Armina*, being broadest near the head and tapering to a narrow posterior end. The foot is narrow, rounded anteriorly, and finely pointed posteriorly. The oral shield is rather broad and rounded, and shows no sign of tentacle formation in the specimen. The notum is broader than the foot and overhangs the body laterally. Anteriorly the edge is broken for the rhinophores; it curves inwards and backwards towards the latter, and can be described as emarginate. Between the rhinophores the notum is prolonged forwards on the neck so that there is no separation between it and the head mesially. Each rhinophore is contracted and lies in a pit. The pattern on the notum is very distinct. It consists of parallel ridges very regularly arranged, and unbranched. Mesial ridges start between the rhinophores, run backwards on the summit of the back, then diverge towards the lateral edges of the notum. Other ridges, evenly spaced, commence posterior and lateral to the rhinophores and take a similar diverging course. Near the edge smaller ridges fill up the increasing gaps between the primary ones. The colour has disappeared from the specimen, but there is evidence that yellow and black or grey were predominant, and also that possibly spots were present, but the colouring is not as well marked as in *Armina.* There is no trace of tubercles. The border of the notum contains nettle capsules. There are no gills or lateral lamellæ. On the right side, between the notum and the foot, the genital, renal and anal apertures are visible.

The specimen was opened from the ventral side and the gut was injected. The buccal mass is large, ovate, and measures 5 mm. by 4 mm. It expands almost at once into a large baggy stomach whose diverticulum extends to the posterior end of the body. This and the stomach receive the bile ducts, as in *Armina,* ten from the left and eight from the right side. In addition, there are smaller ducts entering ventrally from the foot.



TEXT-FIG. 24.—*Dermatobranchus striatus.* *a,* Central and two laterals on each side. × 270. *b,* Central from underside. × 270. *c,* Outermost lateral. × 270.

These are irregularly paired and consist of about 8 or 9 pairs. The first bile duct of the right side, representing the right liver, enters asymmetrically at about the level of the genital opening, the bile duct being dorsal to the genital complex. A short distance behind this, the first duct of the left side enters. This portion of the stomach is thin-walled and its lining is not folded. On its left side lies the exit for the intestine, and there is an abrupt change in the lining, which, starting with a sphincter-like fold, becomes furrowed in all directions, though remaining comparatively thin-walled. The stomach diverticulum tapers with the tapering body, its folds gradually arrange themselves longitudinally, and all the remaining bile ducts from dorsal and ventral sides enter.

A pair of salivary glands with very fine ducts discharge into the buccal mass after piercing the nerve ring. The glands themselves are set far back in the body, that on the right side immediately posterior to the genital complex, or about a third of the way down the body, that on the left side about half-way down. The glands are slender racemose tubes similar to those of *Armina.* They extend forwards beside the ducts, and spread out all round the gut and even over the buccal mass. The mouth aperture is protected by a pair of narrow jaw plates, in which, however, no trace of rod cells could be found. The radula (Text-fig. 24) is of a greenish colour and has 60 rows of very small teeth, the formula for the widest row being 140.1.1.1.140. This does not agree with the numbers given by Bergh and Eliot, who report 31 rows and a formula of 17.1.17, and 20 rows and a formula of 12.1.12 respectively. The teeth have narrow oblong bases and fall off the membrane easily. The rachidian tooth is slight, its base being exceeded by the cusp in width. This cusp is very long, and the overhanging portion of the tooth extends more than half-way over the tooth in the succeeding row. The cusp is bifid at the apex, and bears on each side, after a considerable diastema, from 15 to 25 fine, regular, parallel denticles. The first lateral resembles half a rachidian tooth, but is short and almost square, its cusp hardly projecting beyond its base and bearing eight denticles. Then begins a series of increasingly simpler lateral teeth, each with a long curved and pointed cusp. The first eight show denticulations on the lateral face, the second lateral having from 6–8 denticles, the number being gradually reduced in the others until only one denticle is left. All the remaining teeth in the row are simple. On one side of the radula the 63rd lateral is bifid as if two teeth were fused, and this abnormality is repeated in row after row, though only the 63rd tooth is thus affected.

The hermaphrodite gland is a yellow elongated structure 9 mm. long and 3 mm. broad, lying on the right side, but with its free posterior end veering towards the mid-dorsal line. The hermaphrodite duct lies wholly superficially on its ventral side and the ductules can be plainly seen.

Armina semperi (Bergh). (Text-figs. 25, 26 and 27.)

Pleurophyllidia semperi, Bergh, S.R., 1870–75, p. 249.

Occurrence.—Sta. 194, Gulf of Aden, 7.v.34, 220 metres: twenty-one specimens, varying from 60 mm. long and 23 mm. broad to 30 mm. long and 12 mm. broad.

Distribution.—Indian and Pacific Oceans.

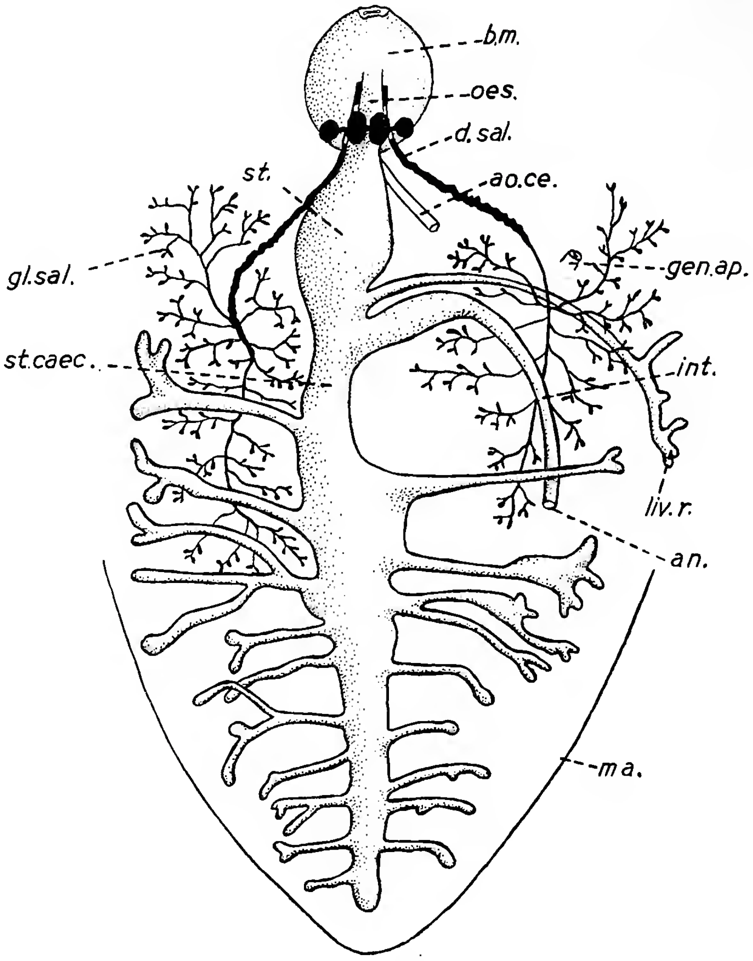
Descriptive Notes.—Bergh gave an account of the external features, jaws and radula of this species, but said very little about the general anatomy. As this differs in many respects from other species of the genus, the gut and reproductive system are here described in some detail.

The preservation of the twenty-one specimens was on the whole good, though there was no trace of the reddish colour described by Bergh. Even the blackness of the mantle and the yellow edge of the longitudinal lines had largely disappeared in many of the specimens. The broad cephalic shield usually retained its yellow margin and the foot its bluish-grey colour. The recurved anterior broadened border of the foot, the paired gills beneath the anterior expanded mantle lobes and the lateral lamellæ extending the whole length of the remaining sub-pallial area were all typical. The unarmed penis was in many of the specimens extruded through the common genital aperture; between the latter and the anus lay the minute renal pore.

Alimentary canal.—The alimentary canal of *Armina* affords a good illustration of the Cladohepatic condition in Nudibranchs, for the hepatic branches extend to the extreme edge of the mantle, and since the hepatic diverticula are large and hollow, an instructive injection can be made of them (Text-fig. 25).

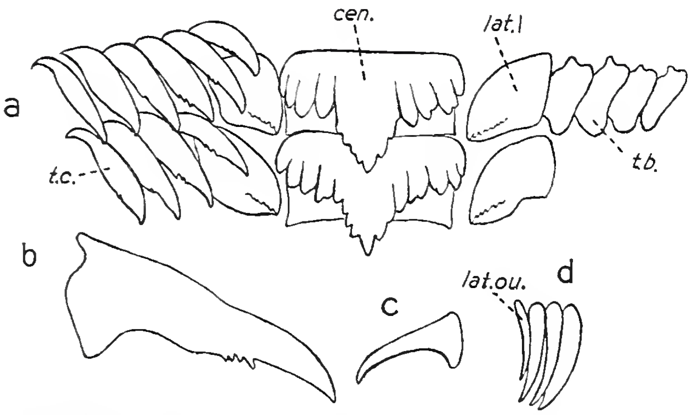
The buccal mass with its large horny jaws and compact radula have been described for this species by Bergh. The radula (Text-fig. 26) has about 40 rows, with a large broad central tooth, whose median cusp is finely denticulate, with from four to five cusps on each side of the median one. The side cusps form a fluted pattern. The first lateral is a short, broad, slightly curved tooth, triangular in cross-section, with fine denticulations on one edge only. The remaining laterals, up to about 50 in number in the broadest part of the radula, are elongated and curved, at first with a few denticles near the middle of one side, but gradually becoming smooth (Text-fig. 26*b*, *c* and *d*).

The paired ducts of the single pair of salivary glands pierce the nerve ring on their way to their apertures into the dorsal portion of the buccal mass beside the œsophagus. Each gland consists of from 18–20 much branched tubes (Text-fig. 25, *gl. sal.*), as fine as a



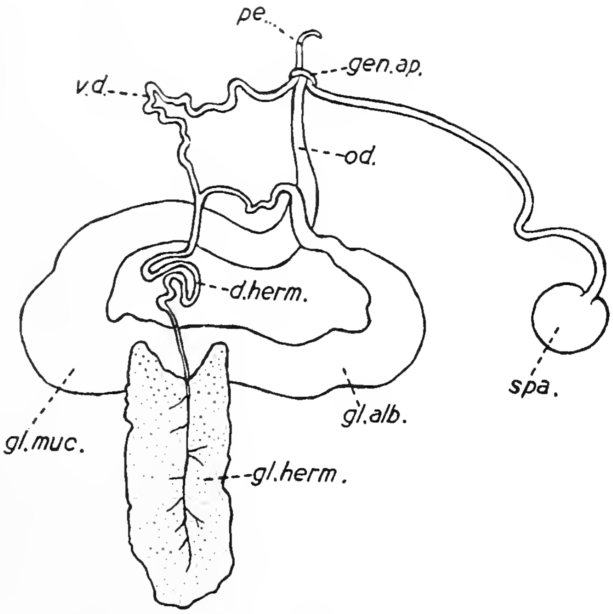
Text-fig. 25.—*Armina semperi*. Alimentary canal, dorsal view. × 2½.

capillary network, lying ventral to all the body organs on the lower surface of the mantle. The main branches unite to form a single stem on each side, and this stem becomes the duct. It is convoluted as it passes forwards, but straightens as it nears the nerve ring. There is no trace of a second pair of salivary glands as described by Bergh in *A. californica*. The œsophagus widens to form the thin-walled stomach (*st.*), which is only slightly larger than the buccal mass. It lies on the animal's left side, ventral to the heart, and ventro-lateral to the voluminous reproductive organs. It receives from the right a wide thin-walled bile duct, bringing the discharge of five or six blunt diverticula situated at the edge of the overhanging mantle flap and representing the right liver lobe. The duct lies dorsal to the body organs and is placed transversely, anterior both to the intestine and the heart. Posteriorly the stomach contracts a little and gives off ventrally an elongated stomach cæcum (*st. cæc.*), which extends to the posterior limit of the body. This cæcum receives the posterior bile ducts or left liver ducts, first a large unpaired duct on the left



TEXT-FIG. 26.—*Armina semperi*. *a*, Part of two rows of the radula. On the left the cusps of the laterals are shown, on the right the bases of laterals 2–5. × 92. *b* and *c*, Lateral teeth. × 92. *d*, Outermost lateral teeth. × 92.

side and then irregularly arranged paired ducts. An injected specimen showed 10 main ducts on the left and 8 on the right side. These ducts are formed by the fusion of a system of reddish diverticula lying within the thinned edge of the mantle. No anastomosis of diverticula was found, though Bergh found such junctions in his specimen. The



TEXT-FIG. 27.—*Armina semperi*. Scheme of reproductive apparatus.

intestine (*int.*) leaves the right posterior portion of the main stomach, turning forwards and dorsalwards over the genital complex. There is no valve separating it from either stomach or gastric cæcum, but a shallow fold, like a typhlosole, runs along its anterior wall. The intestine is short, and becomes more opaque as its walls increase in thickness. It soon takes a right-angled turn backwards and ventralwards, so that the horizontally placed rectum lies ventral to the nearest hepatic cæcum but dorsal to the right salivary gland. It opens to the exterior on the right side of the body under cover of the mantle flap (*an.*).

Reproductive Organs.—*Armina* is hermaphrodite and the genital duct is monaulic (Text-fig. 27). The genital complex forms a compact mass lying on the right side of the body cavity, ventral to the heart and intestine, but dorsal to the rectum and right salivary gland, so that its anterior portion passes under the intestinal bridge on its way to the external aperture, lying at the same horizontal level as the anus but in the anterior third of the body. The posterior portion of the mass is formed by the hermaphrodite gland (*gl. herm.*), a large rounded or triangular body nearly 2 cm. long in the specimen figured. The dorsal side of the gland is formed by the apposition of two distinct halves, though these fuse ventrally. On separating the dorsal halves, the common hermaphrodite duct and its factors can be seen lying on the ventral fused portions. The duct passes straight forwards, then becomes strongly convoluted and thicker walled, forming the ampulla of the duct. The coils can be separated fairly easily. After this the duct straightens again and divides into male and female genital ducts. The male duct lies on the left. It is very long and convoluted. As it approaches the common genital aperture, packed with sperm, its walls thicken, then it becomes suddenly slender for its passage through the unarmed penis. The female portion of the duct courses transversely to the right, passing through the usual albumen and mucus glands, which are coiled, then straight forwards to the common genital aperture. Into this same aperture opens the strong duct of the spermatheca or copulatory vesicle (*spa.*).

Armina tæniolata Bergh. (Text-fig. 28; Pl. I, fig. 5.)

Armina tæniolata, Bergh, 1866, p. 239; Eliot, 1905*b*, p. 239, pl. v, fig. 1.

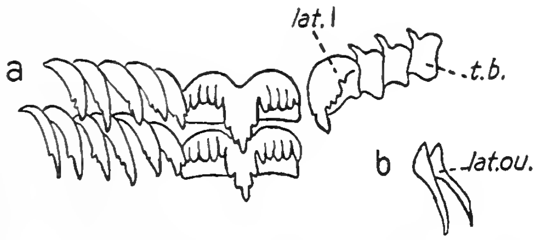
Occurrence.—Sta. 43, South Arabian Coast, near Kuria Muria Islands, 28.x.33, 83 metres; one specimen, 25 mm. long, 15 mm. wide and 6 mm. high.

Distribution.—Indian Ocean.

Descriptive Notes.—The animal is black, with about 40 longitudinal yellow lines on its back, a yellow edge to the cephalic shield, and to the otherwise grey foot. The cephalic shield is not flat and oblong as in *A. semperi*, but has an auriculate margin, as in the oral tentacles of an *Aplysia*. Also the dorsal part of the shield projects over the head in front of the rhinophores as a flap. The rhinophores are bulbous, with longitudinal leaves held in place with a little button-like knob at the tip. The foot is rather thin, with a pronounced yellow rim and grey pedal surface. Posteriorly a pale median streak represents the posterior pedal gland. The anterior margin of the foot is thick, yellow and double, with the usual recurved lateral angles. The gills are well developed. There are about 10 leaves. The lateral lamellæ are very numerous, thick, reddish-brown flaps. There are 35 main lamellæ on the right side, but smaller ones fill the gaps, especially near the edge of the mantle.

The jaws are very delicate, less than half the size of those of *A. semperi* and more elliptical, with a very regular cutting margin made of eight rows of regular and almost symmetrical rod cells, rather pointed in shape. The radula (Text-fig. 28) has 34 rows, with a maximum formula of 32.1.32. It is rather small, with the basal membrane on which the teeth are set extending well beyond the last tooth at the sides. The central tooth has a denticulate median cusp and 4 or 5 pairs of lateral cusps, the latter fluted as in other members of the genus. The first lateral is trihedral, its base almost square, but with a curved projecting process on its postero-lateral corner. The cusp has irregular denticles on its lateral face and some have a small denticle on the mesial edge. The remaining laterals are hooked, set on bases which are almost reniform in shape, becoming narrower and more curved as they proceed lateralwards. Each base (*t. b.*) has a very characteristic curved prolongation from its antero-mesial border. The cusp is long and stout, the first three or four teeth are blunt, but they become increasingly narrowed and more sharply pointed as the distance from the rachidial tooth increases. Denticulations occur nearly halfway down the outer edge of the laterals near the centre of the radula. The first 4–8 teeth bear three (rarely four) denticles, the next 4 teeth two denticles and about 8 further teeth have one denticle. The outer laterals (Text-fig. 28*b*) are simple. None of the teeth are bifid.

The salivary glands resemble those of *A. semperi*. The liver has six branches on the left side, and on the right side are six branches in addition to the main liver duct anterior to the intestine.



TEXT-FIG. 28.—*Armina tæniolata*. *a*, As Text-fig. 26*a*. × 105. *b*, Two outermost laterals. × 105.

The auriculate tentacular shield, very numerous lateral lamellæ and the intense colour of this handsome species were described by Eliot (1905*b*). He also noted the peculiar prolongation of the tooth base on the laterals of the radula, which has not been figured or described in any other species of the genus. Eliot's specimen came from the same region.

Scyllæa pelagica Linn., var. *orientalis* Bergh.

Scyllæa pelagica var. *orientalis*, Bergh, S.R., 1870–1875, pp. 319 and 339; Eliot, 1906*a*, p. 675.

OCCURRENCE.—A single specimen of this almost cosmopolitan pelagic form was collected by the Expedition, but no details of locality were given.

DESCRIPTIVE NOTES.—The animal exhibits no trace of colour or markings, and is somewhat compressed. The head bears a single pair of tentacles, the body two pairs of cerata with much branched branchiæ on their dorsal surfaces. The jaw shows small trifid rods. The radular formula is 21.1.21 and there are 17 rows of teeth. The details of the radula resemble those of Bergh's variety *S. pelagica* var. *orientalis*, but in the absence of any data regarding its location, colour and markings it is difficult to decide definitely. Bergh's variety occurred further east, off the islands of Cebu and Panay in the Philippine group.

SUMMARY AND CONCLUSIONS.

The collection consists of 23 species belonging to 18 genera, from the Red Sea, Gulf of Aden and the South Arabian coast as far east as Maskat. The specimens were taken from near the surface to a depth of 220 metres. Most have already been recorded for this area, though some are not common. Two genera are new to the region. *Phanerophthalmus* has hitherto been found in the Pacific ocean only; *Pleurobranchoides* is known from a single species (two specimens) off the coast of South Africa. On the other hand, the collection can hardly be said to be representative as regards the Nudibranchs. Whole families such as the Bornellidæ, Tethyiidæ, Æolidiidæ and Flabellinidæ are unrepresented, others like the Polyceridæ provide only a single species. Even in the Doridæ, which has the largest number of species, there is only one mangled specimen of the large genus *Glossodoris* (*Chromodoris*), one *Discodoris* and not a single *Dendrodoris* (*Doridopsis*).

There are two new species, and possibly a third. The former are *Artachæa intermedia* and *Phanerophthalmus collaris.* The genus *Artachœa* is confined to the Indo-Pacific area, its three previously known species extending from the Philippines and Japan to Zanzibar and the Red Sea. The new species, *A. intermedia*, from the Gulf of Aden, is in many respects a link between *A. rubida* Bergh and *A. clavata* Eliot. The genus *Phanerophthalmus* has hitherto been confined to the Pacific Ocean, where four species occur. The new species, *P. collaris*, also from the Gulf of Aden, is much broader than the Pacific members, has a large cephalic shield, well-defined eyes and rhinophores, a longitudinally placed, intra-pallial shell, and the foot divided into anterior and posterior regions, so that the parapodial lobes arising from the posterior part of the foot stand up like a collar around the head. The *doubtful* new species belongs to the genus *Pleurobranchoides* O'Donoghue. The single large specimen was badly torn, and though it agrees in many respects with the only known species from South Africa, *P. gilchristi*, it is much larger than the latter, and its radular characters show some differences. As the specimen is imperfect, however, a new name has not been given to it at present.

A useful corollary to the work on the Opisthobranchs collected by the Expedition would be a comparison showing the trends in evolution exhibited by the specimens. The two groups of organs from which most might be expected are the reproductive apparatus and the nervous system. The number of forms described is not large enough to make a comparison of the genital complex profitable, but the author has prepared schemes of the chief varieties amongst the members of this collection (See Text-figs. 12, 16, 18, 20, 23 and 27) in the hope that they will form a nucleus for future work. Such a comparison is badly needed; in the Doridæ alone the accessory genitalia are so imperfectly known that to quote these organs for classificatory purposes, as most systematists do, is bound to be confusing.

With regard to the nervous system, a comparison of the chief types, as shown by Text-figs. 1, 2, 6, 8, 11, 15, 19 and 22, provides a series exhibiting progressive concentration of the nervous system. The least specialized is *Bulla ampulla* (Text-fig. 2), the most specialized, *Hexabranchus sanguineus* (Text-fig. 11). In *Bulla* the cerebral, buccal, pedal, pleural and pallial ganglia (all paired) and the supra-intestinal, infra-intestinal, osphradial, visceral and genital ganglia (all unpaired) are distinct. The pairs, except the buccal, are lateral in position. The unpaired group are linked with the paired group, through the pleuro-pallial ganglia, by a pair of uncrossed pleuro-visceral connectives, but in the most primitive Opisthobranchs, *e. g. Actæon, Akera*, etc., these visceral cords are crossed as in Prosobranchs. Right and left cords have a transverse communication across the ventral side of the gut. The first step in concentration is the incorporation of the left pallial ganglion with the left pleural ganglion (cf. *Phanerophthalmus*, Text-fig. 6), while on the right side the right pallial ganglion may fuse either with the right pleural ganglion (Text-fig. 6) or with the supra-intestinal ganglion (*Hydatina*, Text-fig. 1). Next the infra-intestinal and visceral ganglia, and sometimes also the genital ganglion, unite (Text-figs. 1, 6), then the pleurovisceral cords shorten (*Stylocheilus*, Text-fig. 8), and finally all the unpaired ganglia are incorporated in the nerve circle around the gut (Nudibranchs, Text-figs. 11, 15, 19 and 22), and lie on its dorsal side, like gems on a ring The cerebral commissure is usually short and the cerebral ganglia may be in contact with one another, but the pedal commissure is at least equal to the remaining circumference of the œsophagus. In Nudibranchs the degree of concentration of the dorsal group of ganglia varies greatly. In *Nembrotha* (Polyceridæ) the ganglia are all distinct, with connectives linking the main cerebral, pedal and pleurovisceral ganglia (Text-fig. 15). In the Doridæ (Text-figs. 22, 19) the ganglia are still distinct, but the connectives are so much shortened that the ganglia become contiguous (*Artachæa, Asteronotus*). In the Hexabranchidæ (Text-fig. 11) the fusion is carried to its extreme, and the ganglia of the nerve mass can no longer be traced except by the nerves issuing from them. In the Nudibranchs a pair of new ganglia have arisen as outliers from the cerebral. These are the olfactory ganglia supplying the rhinophores. The eyes are usually sessile on the cerebral ganglia, the width between them being a character of different families and often of genera (cf. Text-figs. 11, 19, 22 and 15 for a series in eye-spacing). The eyes of Tectibranchs, on the other hand, though sessile on the skin, are usually connected with the cerebral ganglia by long slender nerves. These are not shown in the figures.

LIST OF REFERENCE LETTERS USED IN TEXT-FIGS.

a. Anterior end of gizzard plate.
amp. Ampulla of the hermaphrodite duct.
an. Anus.
ar. con. Anal concavity of shell.
ao. ce. Cephalic aorta.

b. Bulb near vagina.
b. m. Buccal mass.
bd. l. First bile-duct.

cen. Central (rachidian tooth).
com. ce. Cerebral commissure.
com. ped. Pedal commissure.
con. ce. buc. Cerebro-buccal connective.
con. ce. ped. Cerebro-pedal connective.
con. ce. pl. Cerebro-pleural connective.
con. v. l. Left pleuro-visceral connective.
con. v. r. Right pleuro-visceral connective.

d. herm. Hermaphrodite duct.
d. sal. Salivary duct.
dt. Dart.
dt. s. Dart sac.

e. Eye.

f.a. Anterior portion of foot.
f.p. Posterior portion of foot.

g. buc. Buccal ganglion.
g. ce. Cerebral ganglion.
g. ce. pl. Cerebro-pleural ganglion.
g. gen. Genital ganglion.
g. inf. Infra-intestinal ganglion.
g. ol. Olfactory ganglion.
g. osphr. Osphradial ganglion.
g. pal. l. Left pallial ganglion.
g. pal. r. Right pallial ganglion.
g. par. Parietal (supra-intestinal) ganglion.
g. ped. Pedal ganglion.
g. pl. Pleural ganglion.
g. pl. l. Left pleural ganglion.
g. pl. r. Right pleural ganglion.
g. visc. Visceral ganglion.
gen. ap. Genital aperture.
gl. alb. Albumen gland.
gl. herm. Hermaphrodite gland.

gl. muc. Mucus (nidamental) gland.
gl. pr. Prostate gland.
gl. sal. Salivary gland.
gl. sal. p. Posterior salivary gland.
gl. ves. Vestibular gland.
gr. do. Dorsal groove of buccal mass.

int. Intestine.

lat. 1, 2, 34. First, second, thirty-fourth lateral tooth.
lat. ou. Outermost lateral tooth.
liv. Digestive gland.
liv. r. Right digestive diverticulum.

m. circ. Circular muscle of gizzard.
m. retr. Retractor muscle of penis.
ma. Mantle.
ma. l. Mantle lappet.
mo. Mouth.

ne. rh. Nerve to rhinophore.

od. Oviduct.
oes. Œsophagus.

ot. Otocyst.

p. Posterior end of gizzard plate.
pe. Penis.
pe. sh. Penis sheath.

r. Rodlet of jawplate.
b. r. Base of rodlet.

sp. Spine.
spa. Spermatheca.
spt. Spermatocyst.
st. Stomach.
st. cæc. Stomach cæcum.

t. b. Tooth base.
t. c. Tooth cusp.

u. Umbo.

v. d. Vas deferens.
vag. Vagina.

w. Wart or cushion for spine.

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DESCRIPTION OF PLATE I.

FIG. 1, *a* and *b*.—Two specimens of *Artachæa intermedia*. × 2. The lower specimen shows the thickness of the body and the blotches on the underside of the mantle.

FIG. 2.—*Phanerophthalmus collaris*. × 9.

FIG. 3.—*Halgerda willeyi*. × 2.

FIG. 4.—*Phyllidiella pustulosa*. × 2.

FIG. 5.—*Armina tæniolata*. × $1\frac{1}{3}$. Posteriorly the mantle skirt has turned upwards, exposing the lamellæ.

FIG. 6.—*Nembrotha lineolata*. × 3.

FIG. 7.—*Dermatobranchus striatus*. × $2\frac{1}{2}$.

FIG. 8.—*Hydatina velum*. × 4.

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[*Adlard & Son, Ltd., Impr.*

BRITISH MUSEUM (NATURAL HISTORY)

THE
JOHN MURRAY EXPEDITION
1933–34
SCIENTIFIC REPORTS

VOLUME V, No. 5

THE ASTACURA AND PALINURA

BY

M. RAMADAN, PH.D.(CANTAB.)

WITH TWO APPENDICES AND TWELVE TEXT-FIGURES

LONDON:
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H.M. STATIONERY OFFICE, LONDON, S.W.1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
1938

Price Two Shillings and Sixpence

[*Issued 26th February, 1938*]

DESIGNED AND
PRINTED
BY
ADLARD & SON, LTD.
21, HART STREET, W.C.
AT
BARTHOLOMEW PRESS
DORKING

Made and printed in Great Britain

THE ASTACURA AND PALINURA

BY

M. RAMADAN, PH.D.(CANTAB.)

WITH TWO APPENDICES AND TWELVE TEXT-FIGURES.

THE John Murray Collection of Astacura and Palinura is a small one, comprising only ten species, of which I have described one as new, belonging to the following Families :

PALINURA.
- ERYONIDEA.
  - Family ERYONIDÆ.
    - *Polycheles andamanensis* Alcock.
    - *P. typhlops* Heller.
- SCYLLARIDEA.
  - Family SCYLLARIDÆ.
    - *Scyllarus arctus* var. *paradoxus* Miers.
    - *S. orientalis* (Spence Bate).
    - *Thenus orientalis* (Rumph.).
    - *Ibacus incisus* (Peron).
  - Family PALINURIDÆ.
    - *Puerulus sewelli* sp. nov.
    - ? *P. carinatus* Borradaile.

ASTACURA.
- NEPHROPSIDEA.
  - Family NEPHROPSIDÆ.
    - *Nephropsis stewarti* Wood-Mason.
    - *N. suhmi* Spence Bate.

Family ERYONIDÆ.

Genus *Polycheles* Heller.

Polycheles, Spence Bate, 1888, p. 143 ; Faxon, 1895, p. 117 ; Alcock, 1901, p. 166 ; Stebbing, 1902, p. 34 ; Kemp and Sewell, 1912, p. 23 ; de Man, 1916, p. 21 ; Bouvier, 1917, p. 34 ; Balss, 1925, p. 200.
Pentacheles, Spence Bate, 1888, p. 143 ; Alcock, 1901, p. 171.
Stereomastis, Spence Bate, 1888, p. 154 ; de Man, 1916, p. 7.

Polycheles andamanensis Alcock.

Polycheles andamanensis, Alcock, 1901, p. 169 ; Illust. Zool. Investigator, Crust., pt. iii, 1895, pl. x, fig. 3.

Occurrence.—Sta. 59, South Arabian coast, depth 1948 m. ; 1 female.

Sta. 62, Northern area of Arabian Sea, depth 1893 m. ; 1 male.

The male specimen measures 45 mm. in length and the female 50 mm.

Distribution.—Off the Travancore coast of India, 1925 m. (Alcock), South Arabian coast and northern part of Arabian Sea.

Polycheles typhlops Heller.

Polycheles typhlops, Kemp and Sewell, 1912, p. 24 ; Selbie, 1914, p. 12, pl. i, figs. 1–13 ; de Man, 1916, p. 24 ; Stephenson, 1923, p. 67 ; Balss, 1925, p. 201, pl. ii ; Calman, 1925, p. 18.
Polycheles agassizii, Faxon, 1896, p. 155.
Pentacheles hextii, Alcock, 1901, p. 172 ; Illust. Zool. Investigator, Crust., pt. iii, 1895, pl. x, fig. 2.

Occurrence.—Sta. 34, Gulf of Aden, depth 1022 m. ; 10 males, 1 female.

Sta. 35, Gulf of Aden, depth 457–549 m. ; 1 male.

Sta. 115, Zanzibar area, depth 640–658 m. ; 3 males, 5 females.

Sta. 145, Maldive area, depth 494 m. ; 2 males.

Sta. 193, Gulf of Aden, depth 1061–1080 m. ; 3 males.

Two large females from Sta. 115 measure 157 mm. and 143 mm. in total length respectively, and are thus larger than any other specimen hitherto recorded from other parts of the world. The latter specimen (143 mm.) is ovigerous and has two spermatophores firmly cemented to the sternal surface between the coxæ of the 4th and 5th legs, while the former (157 mm.) bears three (possibly four) spermatophores in the same position. In the male specimen from Sta. 35 (60 mm.) a spermatophore was found projecting from the left genital orifice to a distance of about 8 mm.

Distribution.—Mediterranean Sea, Atlantic Ocean (West Indies, West of Ireland, Bay of Biscay, Portuguese coast and Cape Verde Islands), Indian Ocean (Andaman Sea, Arabian Sea and South African coast off Natal).

Vertical Distribution.—The species has been taken in the Mediterranean at depths of only 100 m. and 215 m. ; but it is usually caught at much greater depths down to 2050 m.

Family Nephropsidæ.

Genus *Nephropsis* Wood-Mason.

Nephropsis, Alcock, 1901, p. 157 ; de Man, 1916, p. 110 ; Bouvier, 1917, p. 19.

Nephropsis stewartii Wood-Mason. (Text-fig. 1.)

Nephropsis stewartii, Alcock, 1901, p. 159 ; Illust. Zool. Investigator, Crust., pt. iv, 1896, pl. xxvii, fig. 1 ; de Man 1916, p. 112 ; pl. iii, fig. 17 ; Balss, 1925, p. 209 ; Calman, 1925, p. 21.

Occurrence.—Sta. 34, Gulf of Aden, depth 1022 m. ; 1 male.

Sta. 193, Gulf of Aden, depth 1061–1080 m. ; 1 female.

The male specimen measures 108 mm. and the female 135 mm. from the tip of the rostrum to the end of the telson.

Distribution.—East Indian Archipelago (560 m.), Andaman Sea (350–750 m.), Bay of Bengal (500 m.), Arabian Sea (660–850 m.) and African coast, off Natal (425 m.).

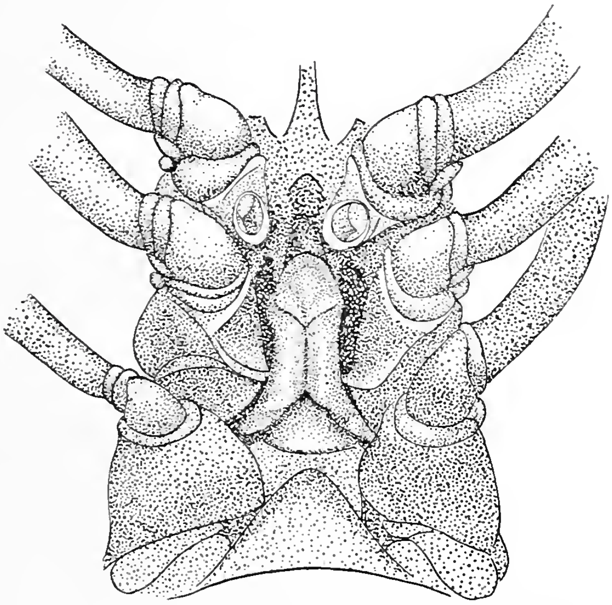
Nephropsis suhmi Spence Bate.

Nephropsis suhmi, Spence Bate, 1888, p. 181, pl. xxiii, fig. 3, pl. xxxiv. fig. 2; Alcock, 1901, p. 163; de Man, 1916, p. 114.

Occurrence.—Sta. 33, Gulf of Aden, depth 1295 m.; 1 female.

Sta. 62, northern area of Arabian Sea, depth 1893 m.; 4 males, 7 females, 1 hermaphrodite.

Sta. 158, Maldive area, depth 786–1170 m.; 1 female.



Text-fig. 1.—*Nephropsis stewarti*. Spermatheca.

The figure of this species given by Spence Bate (1888, pl. xxiii, fig. 3) is not correct; it shows the rostrum to be as long as the carapace and the cervical groove is figured much anterior to where it should be. The actual specimen in the "Challenger" collection in the British Museum (Nat. Hist.) from which the figure is taken has been compared with the figure, and it was found that the rostrum is more than half, but is not as long as, the carapace and the cervical groove is situated posterior to the middle of the carapace.

The rostrum normally carries two spines on either side, but in two females from Sta. 62 it carries three spines on the right side and two on the left; in one male from Sta. 33 it bears no spines on either side. This last specimen also bears no spines on the anterior edge of the 2nd–5th abdominal terga, where usually in this species one or two spines are present.

A specimen from Sta. 62 is peculiar in possessing certain male characters united with those of the female; of the female characters it has a well-developed spermatheca between the 4th pair of legs and an appendix interna on the 2nd pleopod; of the male characters it possesses a petasma, though a reduced one; coxal hooks on the 3rd legs similar to those found in the male, and the genital apertures are situated on the last pair of legs. A similar case of hermaphroditism was recorded by Selbie (1914, p. 52) in a specimen of *Nephropsis atlantica*.

The following are the measurements in mm. of the total length and carapace length of the specimens :

From Sta. 33 : 34 (16).
,, Sta. 62 : 62 (30) ; 57 (27) ; 46 (23) ; 37 (19) ; 30 (15) ; 30 (15).
82 (39) ; 52 (25) ; 41 (21) ; 37 (19).
78 (38).
,, Sta. 158 : 24 (12).

DISTRIBUTION.—East Indian Archipelago, 2029 m. (de Man) ; off Dobba, Arrou Islands, 1474 m. (Spence Bate) and Arabian Sea, 1596–1748 m.

Family SCYLLARIDÆ Gray.

Genus *Scyllarus* Fabricius.

Scyllarus arctus, var. *paradoxus* Miers.

Scyllarus paradoxus, Miers, 1881, p. 364.
Scyllarus arctus var. *paradoxus,* Bouvier, 1917, p. 108, pl. x, fig. 3, and pl. xi, figs. 3, 4 ; Balss, 1925, p. 204.

OCCURRENCE.—Sta. 45, South Arabian coast, depth 38 m. ; 3 males.

The three specimens are small and measure about 22 mm. in total length.

DISTRIBUTION.—Goree Bay, Senegambia (Miers) ; mouth of the Congo River (Balss). The present record increases the range from the west to the east coast of Africa and from the Atlantic to the Indian Ocean.

Scyllarus orientalis (Spence Bate). (Text-fig. 2.)

Arctus orientalis, Spence Bate, 1888, p. 68, pl. ix, fig. 4 ; Alcock, 1901, p. 181.
Scyllarus orientalis, de Man, 1916, p. 73.

OCCURRENCE.—Sta. 16, Gulf of Aden, depth 186 m. ; 1 female.

Sta. 106, Zanzibar area, depth 183–194 m. ; 8 males, 1 female.

Sta. 194, Gulf of Aden, depth 220 m. ; 58 males, 38 females.

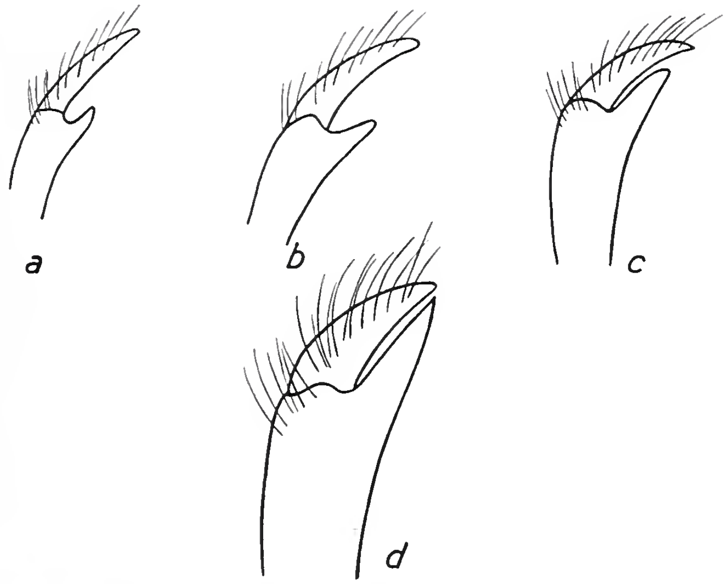
DESCRIPTIVE NOTES.—The carapace, measured in the mid-dorsal line, is approximately as long as the abdomen without the telson, and its length is about equal to its breadth (measured at the antero-lateral angles). In most specimens the 3rd joint of the antennular peduncle reaches by more than three-quarters of its length beyond the antenna ; the 2nd leg reaches by half the dactylus beyond the 1st ; and the 3rd leg as far as the 2nd. The 4th leg, which is the longest in both sexes, reaches by half the dactylus beyond the 3rd, and by a dactylus and a third of the propodus beyond the 5th leg. In the female the 5th pair is perfectly chelate in large specimens, but not in small examples, in which the projecting part of the propodus is still small ; Text-fig. 2 shows the gradual formation of a perfect chela.

The specimens from Sta. 106 differ from the others in that the arborescent markings on the abdominal terga and the sculpturing of the carapace are less distinct.

Of the females from Sta. 194, 21 specimens are ovigerous.

The following are the measurements in mm. of a few specimens of graded sizes; the legs were measured from the proximal end of the basis to the tip of the dactylus.

Sex.	Carapace length.	Carapace breadth.	Abdomen breadth.	Telson.	1st leg.	2nd leg.	3rd leg.	4th leg.	5th leg.
	34	33	35	15	27	33	39	48	47
	30	30	31	14	24	31	36	43	42
♂	27	28	27	13	22	28	33	40	39
	24	25	25	11	17	23	26	33	31
	22	22	21	10	16	20	23	27	26
	33	35	33	16	26	30	36	44	39
	31	32	31	15	25	30	36	42	37
	27	29	27	13	21	26	29	36	31
♀	21	23	22	11	17	20	24	28	23
	18	19	19	9	14	17	19	21	19
	15	16	16	7	12	15	16	19	17



TEXT-FIG. 2.—*Scyllarus orientalis.* Terminal joints of the 5th pair of thoracic legs, × 12, of four female specimens. (*a*) Carapace = 17 mm. (*b*) Carapace = 20 mm. (*c*) Carapace = 24 mm. (*d*) Carapace = 34 mm.

DISTRIBUTION.—Philippine Islands, East Indian Archipelago, Bay of Bengal and Arabian Sea (Arabian and African coasts).

Genus *Thenus* Leach.

Thenus, Stebbing, 1893, p. 193; Ortmann, 1901, p. 1138; de Man, 1916, p. 66.

Thenus orientalis (Rumph.).

Thenus orientalis, Milne-Edwards, 1837, p. 286; Ortmann, 1892, p. 46; Henderson, 1893, p. 433; Nobili, 1906, p. 88; Boone, 1935, p. 58, pls. xiv, xv.

OCCURRENCE.—Sta. 37, Gulf of Aden, depth 18–22 m.; 1 male.

DISTRIBUTION.—East Indian Archipelago, Indian Ocean, Persian Gulf and Red Sea.

Genus *Ibacus* Leach.

Ibacus, Stebbing, 1893, p. 193 ; Ortmann, 1901, p. 1138 ; de Man, 1916, p. 65 ; Bouvier, 1917, p. 103.

Ibacus incisus (Peron).

Ibacus incisus, Stebbing, 1893, p. 194, fig. 16.
Ibacus peronii, Desmarest, 1825, p. 183, pl. xxxi ; Leach, 1815, p. 152, pl. cxix ; Haswell, 1879, p. 168 ; de Man, 1916, p. 65.
? *Ibacus verdi,* Stebbing, 1910, p. 373.

Occurrence.—Sta. 106, Zanzibar area, depth 183–194 m. ; 1 female.

Descriptive Notes.—The specimen measures about 187 mm. from the anterior edge of the carapace between the eyes to the end of the telson.

This species resembles *Ibacus verdi* Spence Bate, but differs from it in the possession of only seven teeth on the lateral edge of the carapace behind the transverse incision, instead of twenty-two in *Ibacus verdi* Spence Bate ; again, the lateral edges of the carapace form, with the lateral edges of the abdomen, an almost straight line, which thus gives to the whole animal a triangular appearance. Stebbing (1910, p. 373) records from South African waters under the name *Ibacus verdi* a specimen which possesses seven teeth on the lateral edge of the carapace behind the deep incision, and it is probable that this example really belongs to *Ibacus incisus* (Peron) and not to *I. verdi* Spence Bate.

Distribution.—Southern seas—Sydney, Valparaiso (de Man) and (?) South Africa (Stebbing).

Family Palinuridæ.

Genus *Puerulus* Ortmann. (Text-fig. 3.)

Puerulus, Calman, 1909, p. 441 ; Gruvel, 1912, p. 6 ; de Man, 1916, p. 35.

The epistome of species of this genus is described by previous authors as being grooved in the middle longitudinal line ; the part which is referred to by these authors as the epistome is, however, not actually the epistome, but the two basal segments of the antennal peduncle, which are fused together, and the groove referred to above represents the line of their fusion. It is true that the epistome is fused with the basal segment of the antennal peduncle, but this fusion is not so complete as to mask the boundaries of both the epistome proper and the basal segment of the peduncle. The proximal edges of the basal segment of the antennal peduncle are very distinct and are clearly marked by the openings of the antennal glands. The epistome proper is not grooved (Text-fig. 3).

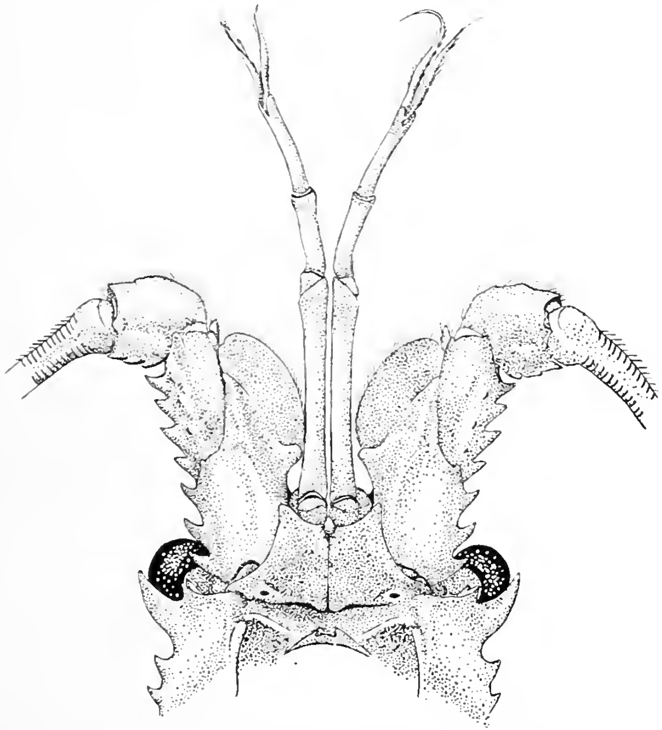
This genus is now represented by three species, namely, *Puerulus angulatus* (Spence Bate = *Puerulus angulatus* de Man), *Puerulus carinatus* Borradaile, and *Puerulus sewelli* sp. nov. (= *Panulirus angulatus* Alcock).

Puerulus sewelli sp. nov. (Text-figs, 3, 4 and 5.)

Panulirus angulatus, Alcock, 1901, p. 185.
Puerulus angulatus (part), Calman, 1909, p. 442.
nec *Puerulus angulatus,* de Man, 1916, p. 36 ; Spence Bate, 1888, p. 81, pl. xi, figs. 2–4.

Occurrence.—Sta. 24, Gulf of Aden, depth 73–200 m. ; 5 males, 8 females.
Sta. 194, Gulf of Aden, depth 220 m. ; 68 males, 5 females.

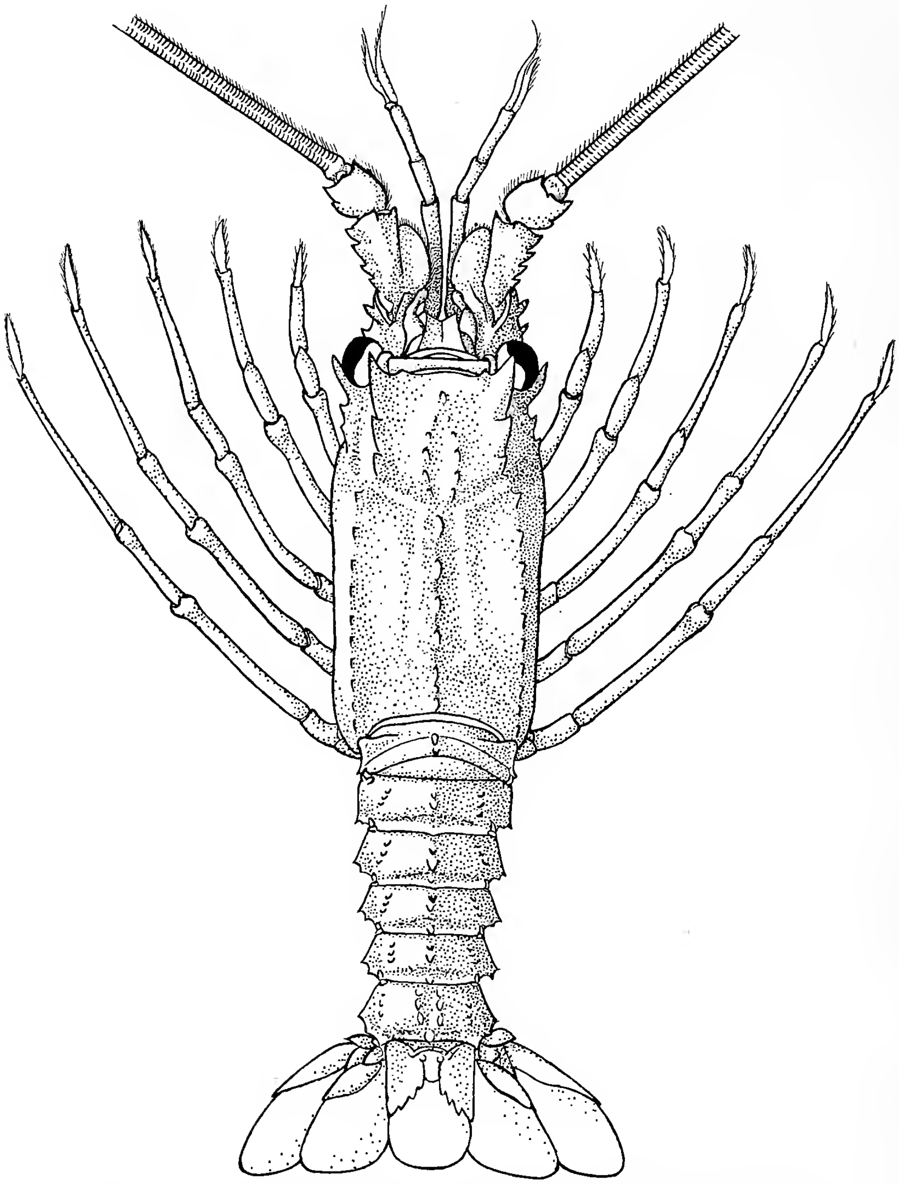
DESCRIPTIVE NOTES.—*Panulirus angulatus* Alcock and *Puerulus angulatus* (Spence Bate) have hitherto been considered synonymous; but the detailed description of *Puerulus angulatus* (Spence Bate) given by de Man (1916, p. 36) is so different from that given by Alcock (1901) of specimens taken by the "Investigator" in Indian waters that he referred to this species, that the specific identity of de Man's and Alcock's examples seemed to be very doubtful. De Man himself pointed out many differences between his specimens and Alcock's description and, commenting on the measurements given by Alcock for one of the examples, he writes, "It is therefore remarkable that in all the specimens taken by the 'Siboga' the abdomen appears almost twice as long as the carapace". From a careful examination of the type-specimen of *Puerulus angulatus* (Spence Bate) in the British Museum and of two examples of Alcock's material, kindly sent to me by the Indian



TEXT-FIG. 3.—*Puerulus sewelli*, sp. nov. Ventral view of epistome and basal segments of antennal peduncles.

Museum, Calcutta, it was found that the specimens from the Indian Museum and the examples taken by the John Murray Expedition are identical, and agree very well with the description given by Alcock, but differ markedly from the "Challenger" specimen and from de Man's description. De Man's examples are undoubtedly identical with Spence Bate's species, and the fact that Alcock did not publish any figures of his examples may perhaps account for de Man's failure to differentiate between these and Spence Bate's species.

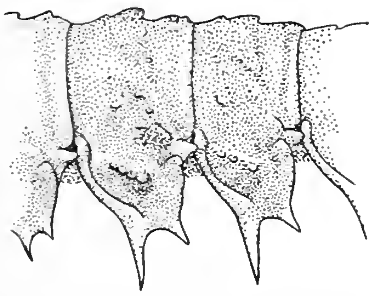
A new species has been established for Alcock's and the present examples, and I have dedicated it to Lieut.-Col. R. B. S. Sewell. Before proceeding to describe this species, attention may be drawn to a wrong statement in Alcock's description; Alcock described the carapace as being "half a telson shorter than the abdomen", and he (*loc. cit.*, p. 186) gives the measurements of a specimen as carapace 70 mm. and abdomen 99 mm., so that if Alcock's statement regarding the length of the carapace were correct, the telson should measure about 40 mm. Dr. B. N. Chopra, of the Zoological Survey of India, at the request of Col. Sewell, very kindly measured some of the specimens in the Indian Museum of Alcock's material and he gives the measurements of the specimen that



Text-fig. 4.—*Puerulus sewelli.* Dorsal view, natural size, male.

is specially referred to by Alcock as carapace 70 mm., abdomen without telson 91 mm. and telson 26 mm. From this he presumes that the length of the abdomen, including the telson, given by Alcock must have been measured without straightening it. Alcock's statement should therefore read, " carapace a telson length shorter than the abdomen ".

The lateral margins of the carapace are cut into three teeth, which decrease in posterior succession, in front of the cervical groove and are serrated behind it. The posterior tooth is not far in advance of the cervical groove. On the inner side of the large supra-orbital tooth there are two small teeth or only a single one that may possess a double head. De Man (1916, p. 37), regarding *Puerulus angulatus* (Spence Bate), writes: "In the 'Challenger' type no teeth did occur between the supra-orbital teeth on the front margin and Col. Alcock does not describe them." These teeth were, however, found to be present in the "Challenger" type of *Puerulus angulatus* (Spence Bate), and also in the two specimens of *Puerulus sewelli* from the Indian Museum. The infra-orbital spine is large, and has below and anterior to it a prominence which is half as long as the spine, and is cut into two teeth, and behind it two other teeth. On the gastric region are two anteriorly convergent, longitudinal rows of eroded spines or elongated tubercles. Behind the cervical groove is a longitudinal carina bearing a row of 7–10 eroded teeth or elongated tubercles, which are of unequal size, and some of which may be double. Usually the last two or three of these are smaller than those anterior to them. The whole surface of the carapace is studded with miliary tubercles, which, on the side walls, are arranged in regular series. The pre-cervical region of the carapace is much shorter than the post-cervical. The transverse part of the cervical groove is very narrow, and from its lateral ends there extend backwards two very shallow grooves, marked by the absence of



TEXT-FIG. 5.—Lateral view of 3–4 abdominal segments of *Puerulus sewelli.*

miliary tubercles. The shape of the region of the carapace enclosed between the cervical groove and these two last mentioned grooves is very characteristic of the species.

The abdominal terga are carinated, the carina of the 6th segment being double. The 2nd–5th terga are transversely grooved near the posterior edge. The carina of the 1st tergum carries a large anterior spine and a smaller posterior one. The carinæ of the 2nd–5th terga each carry two spines anterior to the transverse groove and one posterior to it. Each tergum, from the 2nd to 5th, has at either pleural end a batch of vesicular tubercles in addition to a few small tubercles on either side of the carina. The pleura of the 2nd–5th segments are traversed obliquely by a row of tubercles, and terminate in a pair of teeth which are large in the female and small in the male. The pleuron of the 6th somite ends in a single tooth. The last six thoracic sterna each carry a median tubercle, and the last five have one or two teeth on their raised lateral margins. The 1st abdominal sternum has a transverse row of four spines. The 2nd–5th have each a pair of median spines and the 6th has two transverse rows of spines. These spines are very distinct in the males and young females, but in adult females they almost disappear except on the 1st sternum.

The antennular peduncle is more than half as long as the carapace and the basal segment is longer than the 2nd and 3rd joints together. The antennal peduncle is spinose on its outer margin in adult specimens. In a small specimen from the Indian

Museum it is spinose on both outer and inner margins. In adult specimens the outer margin of the penultimate segment carries four teeth and that of the terminal segment one to three teeth. There is a strong spine at the distal end of the inner margin of the penultimate segment and two very reduced ones on the inner margin of the terminal segment. The antennal flagellum is described by Alcock as being more than twice the length of the body; in none of the specimens from the John Murray Expedition is it complete. The external maxillipeds reach the middle of the 2nd segment of the antennal peduncle and to just beyond the proximal end of the basal segment of the antennular peduncle; its exopodite reaches the middle of the carpus. The proximal halves of the merus and ischium are very strongly serrated on their edges.

In the male the thoracic legs increase in length from the 1st pair, which is about seven-eighths the length of the carapace, to the last pair, which is less than twice as long as the carapace (*vide* the measurements given in the table below). The 1st pair of legs reaches the end of the penultimate joint of the antennal peduncle; the 2nd reaches the end of the terminal segment of the antennal peduncle; the 3rd reaches by half the length of the dactylus beyond the 2nd pair and to the distal end of the 2nd segment of the antennal peduncle; the 4th pair reaches as far as the 3rd and so does the 5th pair. In the female the thoracic legs increase in length up to the 4th pair, and the 5th, which are chelate, are as long as the 4th. The 1st pair of legs reaches the end of the penultimate joint of the antennal peduncle; the 2nd pair reaches the end of the terminal joint of the antennal peduncle; the 3rd pair reaches almost as far as the 2nd, the 4th pair just fail to reaches as far as the 3rd and the 5th reaches the middle of the dactylus of the 4th.

This species differs from *Puerulus angulatus* (Spence Bate) in the following points:

(1) The carapace is much longer in proportion to the abdomen, being almost equal to it without the telson, whereas in *P. angulatus* (Spence Bate) the abdomen is much longer than the carapace (compare the figures given in the table below).

(2) The pre-cervical region of the carapace is much shorter than the post-cervical region, whereas in *P. angulatus* (Spence Bate) the two regions are almost equal. De Man did not give measurements for the two regions in question, but his figure clearly shows that they are almost equal.

(3) The transverse part of the cervical region is very narrow, whereas in *P. angulatus* (Spence Bate) it is broad; the region enclosed between the transverse part of the cervical groove and the two posterior grooves, which extend backward from its lateral ends, differs in the two species and its shape is very characteristic (compare de Man's figure in 1916, pl. xi, fig. 5 of *P. angulatus* with fig. 4).

(4) The 1st pair of legs is only equal to seven-eighths the length of the carapace, the last pair is less than twice the length of the carapace and the last three pairs reach to the same point, whereas in *P. angulatus* the 1st pair are longer than the carapace, the 5th pair in the male is more than twice as long as the carapace, and the last three pairs of legs do not reach to the same point (compare the figures in the table).

(5) The propodus of the 5th pair of legs in the female is more than thirteen times as long as the dactylus, while in *P. angulatus* it is only seven times as long.

(6) The telson is shorter in the present species than in *P. angulatus* (compare the figures in the table on p. 133).

Distribution.—Gulf of Manaar and the Arabian Sea, 264–1327 m. (Alcock).

Puerulus sewelli sp. nov.											*Puerulus angulatus* (Spence Bate).						
Sex.	Total length.	Carapace.	Pre- and post-cervical regions of carapace.	Abdomen without telson.	Telson.	1st leg.	2nd leg.	3rd leg.	4th leg.	5th leg.	Sex.	Total length.	Carapace.	Abdomen without telson.	Telson.	1st leg.	5th leg.
*♂	161	70	29 + 41	65	26	55	..	..	89	94							
♂	145	66	25 + 41	57	22	55	71	81	91	101	♂	145	53	65	27	60	115
♂	134	59	24 + 35	54	21	50	67	77	87	94	♂	134	49	60	25	..	..
♂	133	58	23 + 35	53	22	49	65	79	90	99	♂	133	46	62	25	..	..
♂	122	51	20 + 35	50	21	44	60	73	86	94	♂	123	43	53	23	..	..
♂	116	50	21 + 29	46	20	45	60	72	85	92	♂	116	40	53	23	..	..
♂	112	47	17 + 30	45	20	40	53	..	75	82	♂	110	38	51	21	..	..
♂	50	20	8 + 12	20	10	..	..	..	..	..	♂	42·5†	16·5	18	8	..	..
*♀	187	82·5	35 + 47·5	76	28·5	65	84·5	97	110	106·5	♀	175	60	82	33	66	110
♀	169	74	31 + 43	69	26	61	75	89	99	98	♀	169	56	81	32	..	..
‡♀	166	71	29 + 42	69	26	57	75	86	99	98	♀	164	56	76	32	..	..
♀	166	69	28 + 41	70	27	56	75	..	98	100	♀	164	56	76	32	..	..
♀	157	65	26 + 39	66	26	55	70	84	99	98	♀	155	53	72	30	..	..
♀	135	54	21 + 33	58	23	45	57	70	82	85	♀	134	46	61	27	..	..
♀	123	50	20 + 30	52	21	41	..	..	77	80	♀	122	42	56	24	..	..

(All measurements are in mm.)

* Specimens in the Indian Museum measured by Dr. Chopra ; the male is the specimen specially referred to by Alcock.

† Type-specimen of *Puerulus angulatus* (Spence Bate) in the British Museum.

‡ Specimen in the British Museum received from the Indian Museum.

? *Puerulus carinatus* Borradaile. (Text-figs. 6 and 7.)

? *Puerulus carinatus*, Borradaile, 1910, p. 261, pl. xvi, fig. 5.

Occurrence.—Sta. 105, Zanzibar area, depth 238–293 m. ; 1 female.

Descriptive Notes.—It is with some doubt that this example is referred to this species. The specimen undoubtedly represents a species other than *P. sewelli* sp. nov. and *P. angulatus* (Spence Bate). The type of *Puerulus carinatus* Borradaile no longer exists, and Borradaile's description of the species, in the light of our present knowledge of the specific characters of both *P. sewelli* and *P. angulatus*, does not help in determining the exact systematic position of the species among its congeners. Borradaile does not give any measurements of the different regions of the body. It is thus only from comparison with Borradaile's figure that this specimen is referred to *P. carinatus*.

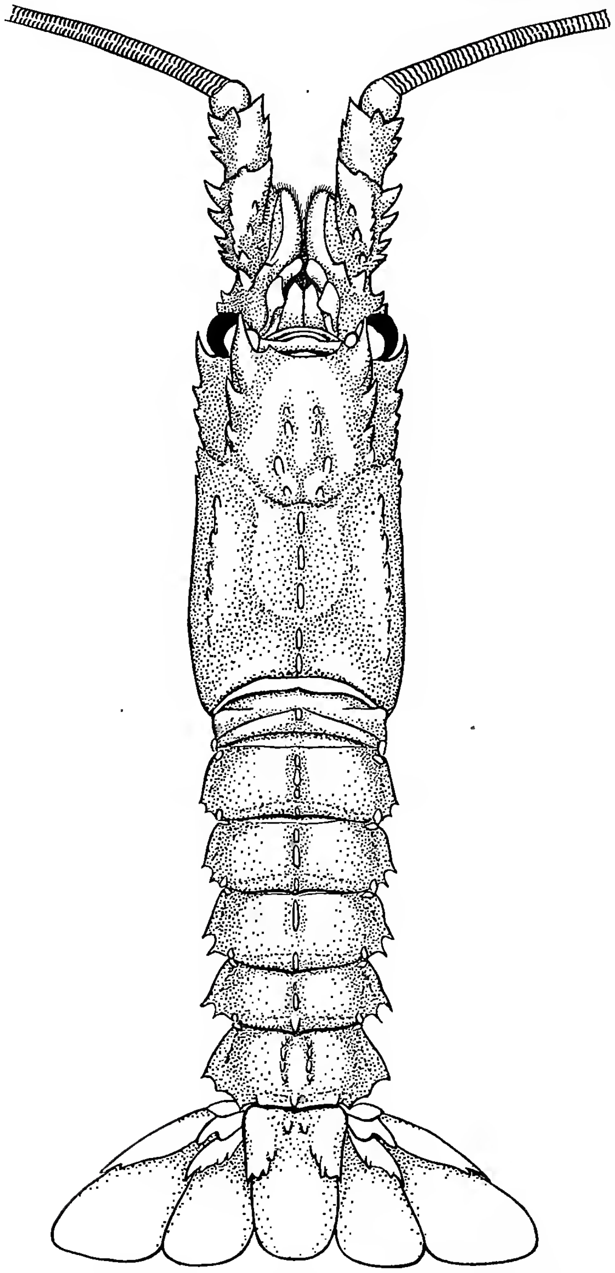
The specimen is intermediate in its measurements between *P. sewelli* and *P. angulatus*.

Total length.	Carapace.	Pre- and post-cervical regions of the carapace.	Abdomen without telson.	Telson.	1st leg.	2nd leg.	3rd leg.	4th leg.	5th leg.
148	56	25 + 31	69	26	48	64	..	99	96

(All measurements are in mm.)

The specimen differs from *P. sewelli* as follows :

(1) The part of the stridulating organ on the 2nd joint of the antennal peduncle is more developed than in *P. sewelli*. When the two 2nd segments of the antennal peduncle of either side are brought into contact with each other along their



TEXT-FIG. 6.—*Pucrulus carinatus* Borradaile. Dorsal view, natural size.

inner edges, the two parts of the stridulating organs also touch, while in *P. sewelli* they do not.

(2) The transverse part of the cervical groove is much broader than in *P. sewelli* and the part of the carapace posterior to it is of a different shape.

(3) The denticles of the median carina of the carapace behind the cervical groove are fewer in number (only five) and more elongated than in *P. sewelli*, and

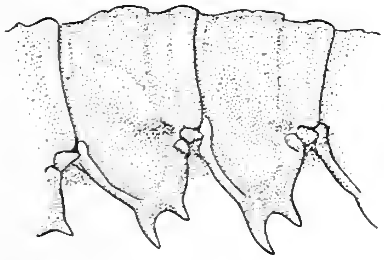
the denticles on the lateral edges of the carapace are also fewer in number (only about seven) and are more developed.

(4) There are three teeth behind the large supra-orbital spine and in front of the cervical groove instead of two in *P. sewelli*.

(5) The denticles on the abdominal pleura and the pleural parts of the terga are obsolete and much less developed than in *P. sewelli*.

(6) The two teeth in which the pleura of the 2nd–5th abdominal segments terminate are of a different shape (compare Text-figs. 5 and 7).

(7) The antennular flagellum shows red and uncoloured alternating bands, while that of *P. sewelli*, is of a uniform tint. These bands could not have existed in *P. sewelli*, and have disappeared through the action of the spirit in which the animal has been preserved, as all the material has been in spirit for the same period and no trace of alternating bands exists in the abundant material of *P. sewelli*.



TEXT-FIG. 7.—? *Puerulus carinatus* Borradaile. Lateral view of 3rd and 4th abdominal segments.

From *P. angulatus* (Spence Bate) this specimen differs mainly in the following :

(1) The relative length measurements of the abdomen and carapace, the pre- and post-cervical regions of the latter and of the legs.

(2) The shape and number of denticles on the median carina of the carapace and its lateral edges.

(3) The propodus of the 5th legs (female) is about twelve times the length of the dactylus, whereas in *P. angulatus* it is only seven times as long.

Borradaile's figure shows : (1) A well-developed stridulating organ on the 2nd joint of the antennal peduncle ; (2) elongate tubercles on the median carina of the carapace and on its lateral edges ; (3) a broad transverse part of the cervical groove. In these respects the specimen resembles Borradaile's figure. The only difference between Borradaile's figure and the present specimen is that in the latter there are three teeth behind the large supra-orbital tooth, whereas the figure shows only two ; but in the figure the 2nd of these teeth is far removed from the cervical groove and it is possible that a very small 3rd tooth may have been overlooked or else was obsolete, as might be expected in such a large specimen (190 mm.).

DISTRIBUTION.—Saya de Malha and Zanzibar area.

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APPENDIX I

ON LUMINOSITY IN PENÆIDÆ, WITH A DESCRIPTION OF THE PHOTOPHORES OF *HYMENOPENÆUS DEBILIS*

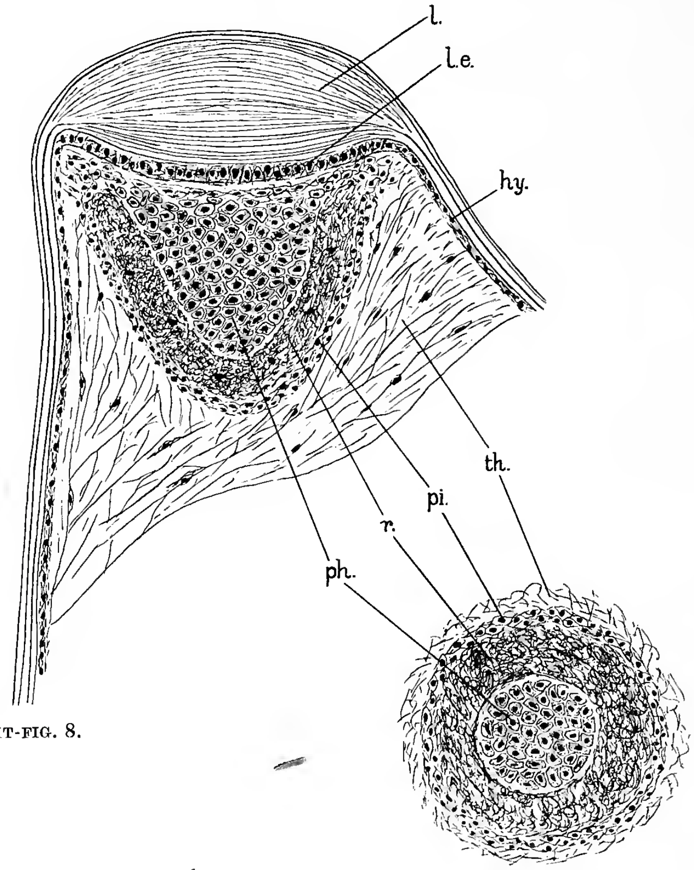
By M. RAMADAN, Ph.D.(Cantab.)

In the family Penæidæ only two species, *Hymenopenæus debilis* and *Plesiopenæus coruscans* (Wood-Mason), are known to possess the property of producing light. Burkenroad (1936, p. 118) suggests that other species of *Hymenopenæus* with large eyes may have photophores. Kemp also (1910*a*, p. 15) suggests that the blue pigment in *Gennadas elegans* may prove to be associated with luminous function. The two species, however, produce light differently. In *P. coruscans* the excretions from or from near the antennal glands have been noticed by Alcock (1902, pp. 134–135) to be brilliantly phosphorescent; the exact origin of such luminous fluids is not known, but Dahlgren (1916, pp. 829–832) concludes that the chemical substance responsible for the luminosity is secreted by some of the integumentary glands. *H. debilis*, on the other hand, possesses fairly well-developed photophores. It may be mentioned that among *Crustacea* the occurrence of compound photophores is limited to the *Eucarida*, and that both types of production of light (*i. e.* the possession of photophores and the ejection of luminous fluid) are not known to occur together except in one species of *Systellaspis* (Harvey, 1931, p. 71). The presence in *H. debilis* of organs which must undoubtedly be regarded as photophores was recently discovered by Burkenroad (1936, p. 112), who, having no time himself for a detailed examination of the organs, has very kindly sent me a few specimens for study. The following is an account of the result of my examination.

The photophores are relatively large, six in number, conical in shape and arranged as follows: (1) A pair on the posterior margin of the sternum of the 7th thoracic segment, just median to the coxæ of the 4th thoracic legs; (2) a pair between the 2nd pleopods; and (3) two unpaired organs placed respectively between the bases of the 4th and 5th pairs of pleopods, and directed posteriorly. In the specimens examined by me the paired organs are larger than the single ones, and it seems that there is a gradual decrease in size from before backwards. The largest organ, including the lens, measures 0·35 mm. by 0·30 mm.

Histological examination of the alcoholic material shows that the photophore is composed of the following parts: (1) The lens, (2) the lens epithelium, (3) the photic cells, (4) the reflector, (5) the pigment mantle, (6) connective-tissue theca, and (7) nerves.

The Lens.—This is a strongly thickened part of the general cuticula of the body and contains layers directly continuous with the three layers of the latter. On the outermost side there is a delicate investing membrane, which is of the same thickness as that investing the general cuticula. Below this is the lens proper, which is bi-convex. Both Hansen (1903) and Kemp (1910) describe the lens of *Sergestes challengeri* as made of two parts, an outer bi-convex and an inner concavo-convex portion. Terao (1917) describes the lens of the photophore of *Sergestes lucens* (the species of *Sergestes*, referred to by Terao as *Sergestes prehensilis*, of the photophores of which he gives a detailed description, is not *S. prehensilis*, but *S. lucens* [see Gordon, 1935, p. 308]) as also made of two parts, an outer *concavo-convex* and an inner bi-convex part. In *Hymenopenæus debilis*, however, the lens does not show any differentiation into parts; it is a simple chitinous structure showing the usual striations. The two main layers of the general cuticula simply merge into it without differentiation into parts.



TEXT-FIG. 8.

TEXT-FIG. 9.

TEXT-FIG. 8.—Longitudinal section of the photophore of *Hymenopenæus debilis*.
TEXT-FIG. 9.—Transverse section of the photophore of *Hymenopenæus debilis*. *l.*, lens; *l.e.*, lens epithelium; *hy.*, hypodermis; *ph.*, photic cells; *r.*, reflector; *pi.*, pigment mantle; *th.*, theca.

THE LENS EPITHELIUM.—This is continuous with the general hypodermal layer, and only differs in that the cells are larger than the normal cells of the hypodermis. In some organs the nuclei of the lens epithelium are pressed against the lens, while in others they are placed in the middle of the cells and in this case the cells are higher than broad. It may be that the cells in such cases represent an active stage and are going to divide, giving rise to photogenous cells. This will be referred to below under the pigment mantle. It might be mentioned here that Terao has noticed in the lens-forming epithelium of *Sergestes lucens* karyokinetic figures, the spindle axis of which is directed vertically to the epithelial layer. The presence of a distinct lens epithelium is emphasized here because in *Sergestes challengeri* (Kemp, 1910*b*) no such layer exists between the lens and the photic cells.

The Photic Cells.—These form a compact pyriform mass. The cells are large and irregular in shape. and their nuclei are fairly large.

The Reflector.—This is of a conical shape and surrounds the photogenous mass, from which. however. it is free. There is no basement membrane, such as that described by Terao. which separates the photogenous mass from the reflector. The reflector is fairly thick and consists of a dense network of protoplasm. which contains a very small number of nuclei scattered in an irregular shape.

The Pigment Mantle.—This consists of a layer of connective tissue 3–4 cells thick. It completely surrounds the reflector and anteriorly enters the space between the lens epithelium and the reflector. Although the alcoholic material, which alone was available to me. contained no pigment, this connective-tissue layer may, from a comparison with the homologous structure in the photophore of *Sergestes lucens*, be assumed to be the pigment mantle. In this latter species a band of connective tissue, external to the reflector, is described by Terao (1917. p. 314. fig. 3) as the pigment mantle. In *Sergestes challengeri*, also, on the outer side of the reflector there is a connective layer which is supposed by Kemp to be the pigment carrier. As to the colour of the photophore in *Hymenopenæus debilis*, Burkenroad (1936. p. 112) writes that in fresh, though dead material the photophores are seen through the transparent cuticle as brilliant scarlet conical bodies with a glistening white base below abutting against the cuticular lens. In this respect (*i. e.* the colour of the photophore) *Hymenopenæus debilis* resembles *Chlorotocoides spinicauda* (de Man) and *Thalassocaris lucida* (Dana), in which the colour is red in the upper part, with a glistening white base (*vide* Kemp. 1925, p. 277). In some photophores there are between the lens epithelium and the photogenous mass some cells similar to the photic cells, but smaller in size. Running between these cells are some connective-tissue fibres, which seem to be derived from the connective tissue of the pigment mantle. These cells are most probably newly formed photic cells. It is difficult to state definitely from the sections obtained whether they owe their origin to the lens epithelium or to the pigment mantle. The first supposition finds support from the fact that Terao, as stated above, has found karyokinetic figures in the lens epithelium of the photophores of *Sergestes lucens*.

The Theca.—This is a band of loose connective tissue surrounding the so-called pigment mantle. The fibres run nearly parallel.

The Nerves.—Both Kemp (1910) in *Sergestes challengeri* and Terao (1917) in *Sergestes lucens* have failed to discover the exact entrance of the nerve into the photophore. Kemp writes that it is not improbable that the nerve-strand runs round the edges of the reflector inwards, in much the same way as has been demonstrated by Chun in the photophore of the Euphausiacea. On the other hand, Terao states that some slender fibres were observed penetrating into the reflector from the internal convex mass and that they were probably of nervous nature. In the photophore of *Hymenopenæus debilis* the entrance of the nerve strand could not be followed right into the inside of the photophore; but it has been followed to such an extent as definitely to exclude the idea of the entrance of the nerve through the reflector. In a series of longitudinal sections of a photophore from the 2nd abdominal segment the nervous strand could be traced until it entered the theca, and it was then found to run parallel and close to the pigment mantle on the outer side of the photophore; it is thus very probable that the entrance of the nerve into the photogenous mass is of the same type as in the Euphausiacea, as suggested by Kemp.

The photophores of *Hymenopenæus debilis* differ from those of *Sergestes lucens* and *S. challengeri* in that they are (i) larger in size ; (ii) fewer in number, only six being present * ; (iii) of a different shape, being conical rather than spherical ; (iv) differently distributed ; (v) of a different colour ; and (vi) of a different structure. The internal structure differs considerably from that of the photophores in *Sergestes*, for they possess no basement membrane, such as that described by Terao, separating the photogenous mass from the reflector ; but the most important difference is that in *Sergestes* the photogenous mass consists of a single layer of cells, whereas here it is composed of a pyriform mass of cells.

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* Gordon (1935, p. 308) states that in *Sergestes gloriosus*, Kemp, who in the course of his work on board the " Discovery " made a careful study of the photophores, found that the total number present varied with age and size, and Kemp (1910, p. 61) states that in *Acanthephyra debilis* A. M.-Edw., " the larval form possesses only twelve photophores (six pairs), while no less than one hundred and forty-seven are to be found in the largest specimens ". In the present species photophores to the same number, six, are present in all post-larval stages.

APPENDIX II

ON THE STRUCTURE OF THE OCULAR PEDUNCLES IN DEEP AND SHALLOW-WATER FORMS OF THE PENÆIDÆ*

By M. RAMADAN, Ph.D.(Cantab.)

The following study of the ocular peduncles of the Penæidæ was carried out with the object of discovering to what extent, if at all, the several groups of the family differ from one another in respect of the general structure of these organs, and whether any of the observed differences can be correlated with differences of habitat.

In the Aristæinæ the ocular peduncle is simple and the cornea is, as a rule, hemispherical; whereas in the Penæinæ and Eusicyoninæ the peduncle is complex and the cornea is always reniform. The fact that the Penæinæ and Eusicyoninæ are littoral forms and the Aristæinæ are deep-sea forms suggests that these differences, as roughly outlined above, may be due to adaptation to their different habitats; the answer to this question, namely, whether such differences are really due to habitat-adaptation, must be sought in the members of the Solenocerinæ, some members of which are truly abyssal, while others live in comparatively shallow waters, inhabited also by some members of the Penæinæ.

Among the Penæidæ two types of ocular peduncle are present, namely, a simple type and a complex one.

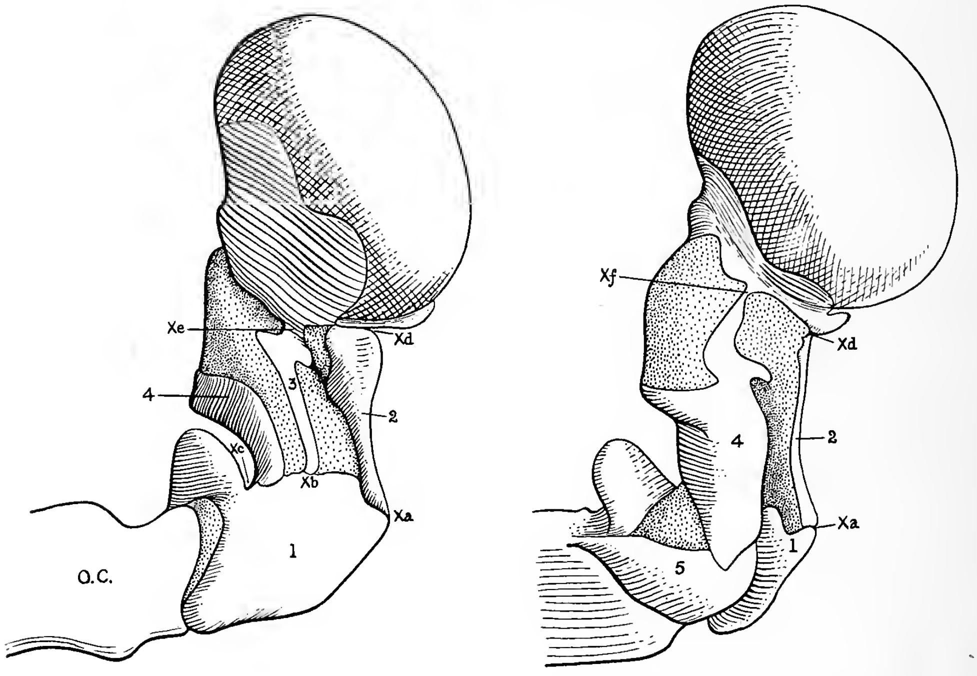
Simple Peduncle.—In this type the peduncle is very simple and the condition found in *Plesiopenæus edwardisianus* may be taken as representative (Text-fig. 12, *c*). The cornea is hemispherical and the peduncle is composed of two segments, the 1st or proximal being much smaller than the 2nd. The wall of the two segments is of uniform thickness. When the peduncle is moved, the position of the cornea changes with reference to the long axis of the animal.

Complex Peduncle.—In this second type the eye is usually reniform, the inner side of the eye and a portion of the dorsal side being blind (Text-figs. 10, *a* and *b*). If the articulation of the segments of the peduncle were as in the simple type, on the abduction of the peduncle the inner or blind side of the eye would be swung into a position occupying the sector for anterior vision. To avoid this a special peduncular mechanism has been evolved in order to keep the cornea always in the same plane with reference to the long axis of the organism, and thus prevent the inner blind side of the eye from occupying the sector for anterior vision. I give below a description of the peduncle of *Penæus trisulcatus*, a species that possesses this type of mechanism, and show how the mechanism is effective.

In this peduncle (Text-fig. 10) the exact limitation between a first and a second segment

* I wish to express my thanks to Mr. M. D. Burkenroad, of the Peabody Museum, Yale, who suggested to me a study of the habitat adaptations of the Penæinæ. Owing to lack of time the work was confined to a study of the eyes and ocular peduncles.

is not clearly seen. While on the dorsal side one may say that there are two segments, it is almost impossible from the ventral side to tell what belongs to the 1st and what to the 2nd segment; for this reason in the following description no reference will be made to individual segments, but the whole peduncle will be considered as a single unit. The walls of the peduncle are not of uniform thickness; there are a certain number of sclerites, between which the wall is very soft. Besides the sclerites the part which forms the inner blind side of the eye is composed of fairly hard chitin. Sclerite 1 is firmly attached to the ocular somite and is bent on itself posteriorly, the bent part being visible on the ventral side. Sclerite 2 lies on the lateral side of the peduncle, and is attached posteriorly to sclerite 1 and anteriorly to the blind part of the eye. Sclerite 3 is dorsal in position, and is attached posteriorly to sclerite 1 and anteriorly to the eye. Sclerite 4



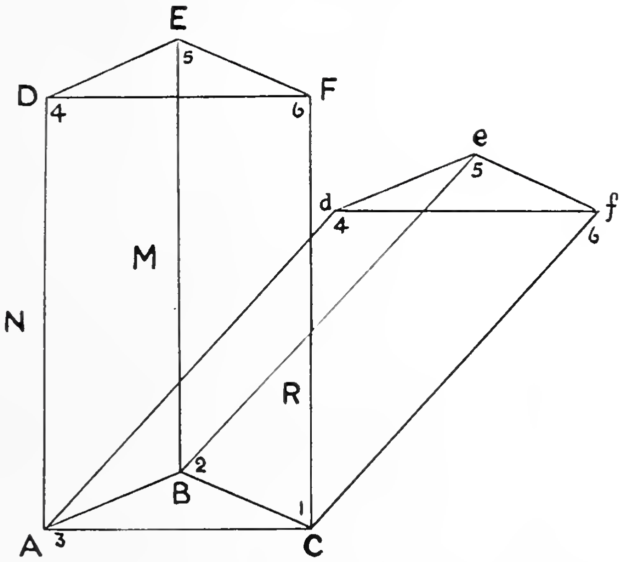
TEXT-FIG. 10.—Ocular peduncle of *Penæus trisulcatus*. *a*, Right eye, dorsal view; *b*, left eye, ventral view.

is very broad and occupies part of the inner side of the peduncle and a good part of the ventral side, as well as appearing on the dorsal side also; it is attached to sclerite 1 and, anteriorly, to the eye. Sclerite 5 is ventral and is attached posteriorly to the ocular somite and anteriorly, through a small flexible piece, to sclerite 4. Dorsally on the inner side of sclerite 2 there is a cavity, the walls of which are composed of soft tissue, and ventrally on the inner side of the same sclerite there is a second cavity of the same nature; both cavities, with the movement of the eye, take different shapes. The parts at which the sclerites articulate with each other (marked × in the figures) act as a kind of hinge, which permits movement, but is not extensible.

The mechanical action of the apparatus described in the foregoing paragraph is as follows: Sclerites 2, 3 and 4, supporting the eye on their distal ends, can swing to and from the median line on their articulations in such a manner that the eye retains its relation to the long axis of the body. This is shown in principle in the diagram (Text-fig. 11). Plates ABC and DEF are comparable respectively to sclerite 1 and the sclerite which forms the blind side of the eye. The lines N, M and R are comparable to sclerites 2, 3 and 4. In whichever direction N, M and R move, plate DEF will remain parallel to plate ABC. Since sclerite 1 is fixed to the ocular somite, the eye thus retains its relation to the latter and to the longitudinal axis of the animal.

THE DISTRIBUTION OF THE TWO TYPES OF PEDUNCLE IN THE PENÆIDÆ.

The simple type of peduncle occurs in the Aristæinæ: the complex peduncle is found in the Penæinæ, Eusicyoninæ and Solenocerinæ, and in the Penæinæ and Eusicyoninæ is of the type described in *Penæus trisulcatus*. In these two sub-families, with the single exception of the genus *Funchalia*, the eye is reniform and the inner blind area of the eye



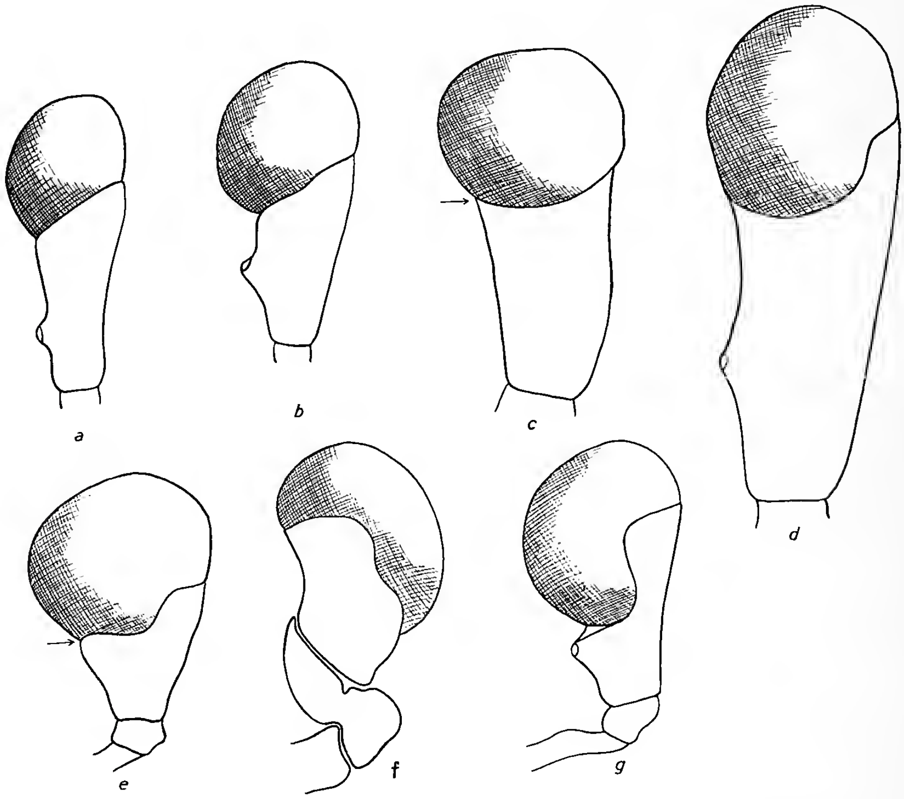
TEXT-FIG. 11.—Diagram illustrating the mechanism of the complex peduncle.

is large. Species of the following genera were examined by me: *Eusicyonia*, *Penæus*, *Funchalia*, *Metapenæus*, *Atyopenæus*, *Parapeneopsis*, *Xiphopenæus*, *Trachypenæus*, *Peneopsis*, *Parapenæus*, *Artemesia* and *Macropetasma*.

The most complex type of peduncle is found in species of *Penæus*. In *Parapenæus fissurus* (Text-fig. 12, *f*) and other species the chitinous structure, which forms the inner blind side of the eye, extends backward, covering the articulations (Xd, Xe and Xf), and sclerite 1 (Text-fig. 10) extends forward, so that, when the eye is in the normal position, the whole mechanism is concealed.

This type of complex peduncle is transitional to the state of affairs which we find in the Solenocerinæ, in which the mechanism is so reduced that the complex peduncle may easily be mistaken for a simple one.

Among the Solenocerinæ there is a steadily progressive development of complexity in the peduncle in the several species as we pass from the depths upwards to the littoral region. In *Solenocera*, a genus which lives at far shallower depths than some species of *Hymenopenæus* and *Haliporus*, we find the highest development of the peduncle in the sub-family. In some species of the genus, *e. g. Solenocera hextii*, the peduncular mechanism is almost as highly developed as it is in the Penæinæ, while in others, *e. g. S. africanus*, although the mechanism is as developed as it is in any of the species of the genus, there is a backward prolongation of the eye sclerite which recalls the peduncle of *Parapenœus*. In *Hymenopenœus* there are different degrees of development of the peduncle, which can be correlated with the depth of habitat. In all the species of this latter genus the eye sclerite is prolonged backwards. The higest degree of development in the genus is found in *H. mulleri*, a littoral form from 13–80 metres ; here the three sclerites 2, 3 and 4 (Text-fig. 10) are well developed and the character of the peduncle comes near to that of



Text-fig. 12.—Ocular peduncle of (a) *Hepomadus tener* ; (b) *Hemipenœus crassipes* ; (c) *Plesiopenœus edwardisianus* ; (d) *P. armatus* ; (e) *Aristeomorpha foliacea* ; (f) *Parapenœus fissurus* ; (g) *Aristeus alcocki*. The arrow indicates the position of the ocular tubercle.

Parapenœus. In species living at greater depths than that inhabited by *H. mulleri*, namely, in *H. triarthus* and *H. sibogœ* from about 450 metres depth, there is a less developed peduncular mechanism, and in *H. neptunus* and *H. lœvis*, two species which live at still greater depths, we find a further degree of simplification in the peduncle. In the latter species the three sclerites 2, 3 and 4 are much shorter and weaker and the eye sclerite is much prolonged backwards. Associated with this prolongation of the eye sclerite there is a backward shifting of the sclerite articulations, Xd, Xe and Xf, from near the eye to the proximal part of the peduncle. In *Haliporus curvirostris*, an abyssal form from 2340 metres depth, the reduction has proceeded to the extreme ; the three sclerites are very feeble and very short, the backward prolongation of the eye sclerite has gone on to a high degree, so that it now gives one an impression of representing segment 2 of the simple peduncle of the Aristæinæ. There is thus but little doubt of the relationship between the degree of development of the complex ocular peduncle and the depth at which the species lives.

If the complex type of peduncle has arisen from the simple type, as would seem to be most probable, then clearly its development is associated with the possession of a reniform type of eye, and the necessity of preventing the blind side of the eye from being brought into the forward position when the peduncle is swung outwards. Hence a complex peduncle should be associated with a reniform eye and the simple peduncle with a hemispherical one : and this is actually the case except for three exceptions.

In *Aristeus* (Text-fig. 12, *g*) the peduncle is simple, but the cornea is reniform, when we should expect it to be hemispherical : in this species, however, the blind side of the eye, contrary to the condition found in the Penæinæ, is on the *outer side* of the eye and thus will not interfere with anterior vision when the peduncle is swung outwards. The second exception is *Hymenopenæus mulleri*, which possesses a hemispherical, instead of a reniform, eye ; but of all the Solenocerinæ examined this species inhabits the shallowest waters, occurring between 80 to as little as 13 m. depth, and it is therefore practically littoral in its habitat, and one would expect the peduncle to be as highly developed as in the Penæinæ. Actually the peduncle is only moderately developed, and hence we get the necessity for the hemispherical type of eye to counter-balance the lower efficiency of the peduncle.

We are thus left with the third instance, the genus *Funchalia*, as the only real exception, and here we are dealing with a form that has a very special habitat, namely, the upper surface layers of the open ocean, and we thus find the maximum degree of efficiency, namely, the combination of a hemispherical type of eye with a highly complex ocular peduncle.

Table of Species Examined, Showing the Type of Peduncle, the Degree of Development, the Shape of Cornea and the Depth at which the Species Lives.

Species.	Type of peduncle.	Degree of development of peduncle.	Depth.	Shape of cornea.
Sub-family EUSICYONINÆ :				
Eusicyonia	Complex	++++	Littoral	Reniform
Sub-family PENÆINÆ :				
All genera except *Funchalia* (*vide supra*, p. 145)	,,	++++	,,	,,
Funchalia	,,	++++	Upper waters of the ocean	Hemispherical
Sub-family SOLENOCERINÆ :				
Solenocera hextii	,,	+++	119–505 m.	Reniform
S. africanus	,,	+++	61 m.	,,
Hymenopenæus mulleri	,,	+++	13–80 m.	Hemispherical
H. triarthus	,,	++	400 m.	Reniform
H. sibogæ	,,	++	450 m.	,,
H. neptunus	,,	+	3109 m.	,,
H. lævis	,,	+	878–1957 m.	,,
Haliporus curvirostris	,,	Almost simple	4279 m.	,,
Sub-family ARISTÆINÆ :				
Aristeus alcocki	Simple	..	270–1022 m.	,,
Hemipenæus crassipes	,,	..	500–1737 m.	Hemispherical
Plesiopenæus edwardisianus	,,	..	550–1850 m.	,,
P. armatus	,,	..	750–5400 m.	,,
Aristeomorpha foliacea	,,	..	400–1300 m.	,,
Hepomadus tener	,,	..	2304–3140 m.	,,

BRITISH MUSEUM (NATURAL HISTORY)

THE JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME V, No. 6

PYCNOGONIDA

BY

W. T. CALMAN, C.B., D.Sc., LL.D., F.R.S.
(*Lately Keeper of Zoology*)

WITH TEN TEXT-FIGURES

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H.M. STATIONERY OFFICE, LONDON, S.W. 1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W. 7
1938

Price Two Shillings and Sixpence

[*Issued 26th February*, 1938]

DESIGNED AND
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21, HART STREET, W.C.
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Made and printed in Great Britain

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WITH TEN TEXT-FIGURES.

The Pycnogonida obtained by the Expedition are referred to fourteen species, of which six are described as new. Among the latter the species of *Eurycyde* and *Cilunculus* are of interest because of their well-marked characters, and because they belong to genera including only a few other species. The form described as *Callipallene echinata* is provisionally allotted to the genus *Callipallene*, but it presents several unusual features that will probably require its removal to a new genus when the accumulation of adequate material allows a revision of the related genera.

Of the other species identified in the collection, *Rhopalorhynchus kröyeri*, already known to range from Queensland to the Maldives and the Persian Gulf, was found in the Red Sea, the Gulf of Aden, and off the South Arabian Coast. It is abundant in some localities in shallow water.

The names given to the species of *Nymphon* recorded below are to be regarded merely as provisional determinations. They do no more than record the existence in these waters of a number of closely related forms, whose specific identity, mutual relations and geographical range will remain uncertain until someone with access to abundant material of fully adult specimens will produce a revision of the tropical and northern species like that provided by Dr. Gordon for the Antarctic members of the genus.

The most interesting species in the collection from a geographical point of view is *Colossendeis angusta*, from deep water in the Gulf of Aden. As pointed out below, this species has an extremely wide distribution, always in cold water at great depths, and it seems likely that its presence in the Gulf of Aden can be correlated with large-scale movements of the bottom water.

LIST OF SPECIES.

Family Colossendeidæ.
- *Colossendeis angusta*, G. O. Sars.
- *Rhopalorhynchus kröyeri*, Wood-Mason.

Family Eurycydidæ.
- *Eurycyde extenuata*, sp. n.

Family Nymphonidæ.
- *Nymphon andamanense*, Calman.
- ,, *foxi*, Calman.
- ,, *arabicum*, sp. n.

Family Phoxichilidæ.
Callipallene pectinata (Calman).
,, (?) *echinata*, sp. n.
Parapallene longipes, sp. n.
Family Phoxichilidiidæ.
Pallenopsis brevidigitata, Möbius.
Family Endeidæ.
Endeis mollis (Carpenter).
Family Ammotheidæ.
Achelia echinata, Hodge.
Cilunculus sewelli, sp. n.
Family Pycnogonidæ.
Pycnogonum africanum, sp. n.

Colossendeis angusta, G. O. Sars.

G. O. Sars, 1877, p. 368 (error for 268); *id.*, 1891, p. 140, pl. xv, fig. 2, *a–f*; Topsent, 1891, p. 178; Möbius, 1902, p. 191, pl. xxix, figs. 6–13; Bouvier, 1917, p. 8.
C. gracilis Hoek, 1881, p. 69, pl. ix, figs. 6–8, pl. x, figs. 6 and 7; Schimkéwitsch, 1893, p. 32.
C. gracilis var. *pallida*, Schimkéwitsch, 1893, p. 33, pl. ii, fig. 25.

Occurrence.—St. 185, Gulf of Aden, 2000 m. Bottom temperature probably 3·5° to 4° C. (Sewell). 2 ♀.

Distribution.—Perhaps world-wide, always in cold water and (except in the Arctic) at considerable depths. With reference to the present specimens Lt.-Col. Seymour Sewell remarks (*in litt.*), " I think that without doubt the species has come along with the Antarctic Bottom Drift up the East Coast of Africa or else with the deep Atlantic water that enters the Indian Ocean round the Cape of Good Hope ".

Remarks.—I follow Topsent, Möbius and Bouvier in identifying Hoek's *C. gracilis*, from between the Crozet Islands and Kerguelen, with Sars's *C. angusta* from the North Atlantic and Arctic. Möbius's record of the " Valdivia " specimen (which Bouvier, by a slip, attributes to the " Siboga ") from 2959 metres off Dar-es-Salaam, bottom temperature 2° C., forms a link between the new record from the Gulf of Aden and Hoek's locality in the far South, 1375–1600 fathoms, temperature 0·8° to 1·5° C.

Schimkéwitsch's identification of *C. gracilis* and a variety *pallida* from "Albatross" dredgings off the west coast of Central America provides the only other certain record outside the North Atlantic and the Arctic, but if *C. brevipes* and *C. media* are to be included, as Hoek suspected, the South Atlantic and the South-East Pacific must be added to the range of the species.

Möbius was justified in suspecting an error in Hoek's statement that the third pair of legs are the longest in *C. gracilis*. In the " Challenger " types, as in *C. angusta* from the North Atlantic and in the specimens in the present collection, the second pair are the longest.

Specimens of *C. angusta* from the North Atlantic are much larger than Hoek's types and the legs are relatively shorter. The ocular tubercle is lower and more rounded. The specimens now recorded agree with those of Hoek. The ocular tubercle is tall and acute and, although there is no pigment, the anterior pair of eyes at least are clearly indicated.

The relative length of the legs is much less than in the specimen recorded by Möbius, those of the second pair being a little less than four times the total length of the body and proboscis.

As described by Hoek, one of his co-types retains the chelophores, but it has not been mentioned that the other two show scars marking the place of articulation of these deciduous appendages. The scars are still more plain in large specimens from the North Atlantic, but the present specimens show no distinct trace of them.

Rhopalorhynchus kröyeri, Wood-Mason.

Calman, 1923, p. 268, text-fig. 1 (with synonymy).

Occurrence.—St. M.B. (*b*) 17.ix.33, Red Sea, 29 m., 11 spms. St. M.B. (*d*) 17.ix.33, Red Sea, 26 m., 61 spms. St. 27, 12.x.33, Gulf of Aden, 37–91 m., 1 spm. St. M.B. II*b*, 28.x.33, S. Arabian coast, 29 m., 1 spm.

Recorded Distribution.—Port Denison, Queensland (Haswell); Torres Straits (Carpenter); Andamans (Wood-Mason); N.E. of Ceylon, 88 fms. (Calman); Maldives and Saya de Malha, 47 fms. (Carpenter); Muscat (Calman).

Remarks.—The specimens in this collection afford no reason for modifying the synonymy given for this species (Calman, 1923, p. 268). All of them show characters of the *gracillimus* type, the proboscis being drawn out anteriorly, with the dorsal tooth well back on the inflated part. The claw on the legs is always between one-half and two-thirds of the length of the propodus.

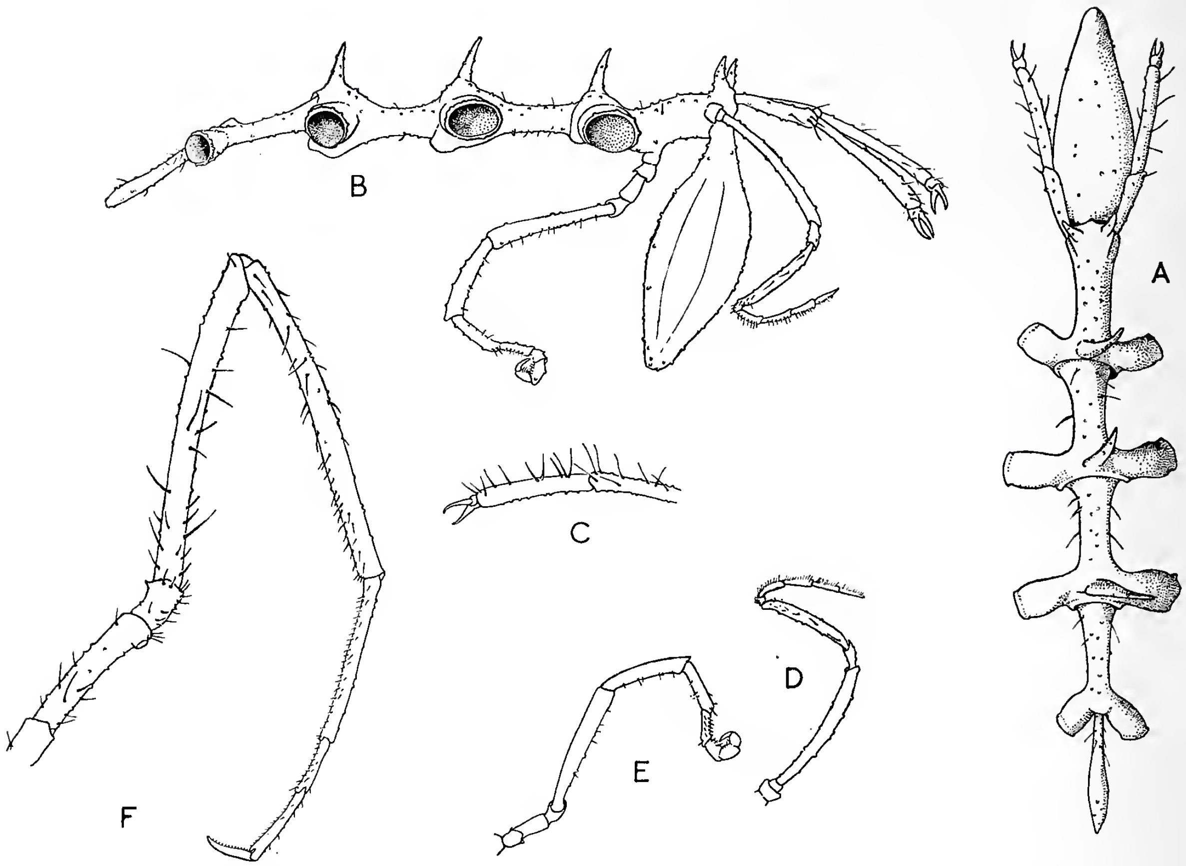
I cannot confirm Loman's statement (1908, p. 26) that the sexes are easily separated by differences in the length and shape of the femora. Specimens recognized as males and females by the size and position of the genital apertures (that of the male being very minute and much nearer the distal margin of the coxa than that of the female) have the femora precisely similar. Possibly the more clavate femora of the female figured by Loman are characteristic of a later stage of maturity.

Eurycyde extenuata, sp. n.

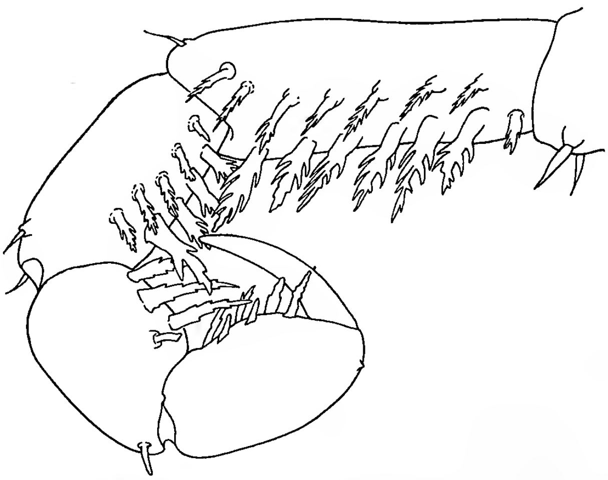
Occurrence.—St. 120, Zanzibar area, 2926 m., 3 ♀. St. 121, Zanzibar area, sounding 925 m., " net apparently not at bottom ", 1 ♀.

Description.—Body and limbs beset with minute scattered tubercles. *Trunk* slender and much elongated. Cephalic segment little longer than the second or third somite, each of which is again a little longer than the fourth. Neck about one-fourth of width across the first lateral processes, little expanded in front where a pair of spines overhang the bases of the chelophores. Width across second lateral processes more than one-third of length of trunk, and nearly six times the width between second and third processes. Distance between second and third processes about three times the diameter of the processes. Cephalic and two succeeding segments each with a median dorsal spine on hind margin. No ocular tubercle. Each of the last three segments cylindrical in front of the lateral processes, expanding to the wide articulation with the preceding segment. *Proboscis* fusiform, deflexed, with minute scattered tubercles. *Abdomen* slender, cylindrical, bluntly pointed, reaching to middle of second coxa of last legs.

Chelophores shorter than proboscis; scape of two segments, the first about two-thirds as long as the second; chela minute, the acutely pointed fingers curved, apparently incapable of apposition.



Text-fig. 1.—*Eurycyde extenuata*, sp. n. A, Dorsal view of body with chelophores. B, Lateral view of body with chelophores, palp, and oviger. C, Chelophore. D, Palp. E, Oviger. F, Third leg of right side.



Text-fig. 2.—*Eurycyde extenuata*, sp. n. Terminal segments of oviger further enlarged.

Palps longer than proboscis, second segment not quite twice as long as fourth, fifth shorter than any of the following four, which are subequal.

Ovigers inserted a little way in front of the first lateral processes. Fourth segment twice as long as fifth.

Legs.—Femur a little shorter than first tibia, which is twice as long as second. Carpus nearly two-thirds of propodus.

Measurements in mm.:

Length of proboscis	3·0
,, trunk	6·0
,, abdomen	1·35
,, chelophore	2·25
Third right leg:	
First coxa	0·6
Second ,,	1·7
Third ,,	0·6
Femur	3·8
First tibia	4·0
Second ,,	2·0
Tarsus	0·6
Propodus	1·0
Claw	0·4

Remarks.—Loman (1908, p. 29) distinguished the genus *Eurycyde* from *Ascorhynchus* by two characters only, the stalked proboscis and the longer chelophores, both of which he admitted to be unsatisfactory. In the two species which he described from the "Siboga" collections the "stalk" of the proboscis is much less distinct than in the genotype *E. hispida*, and hardly more so than the basal part that is defined from the body of the proboscis by a groove in most species of *Ascorhynchus*. The present species, in which this groove is hardly perceptible, is referred to *Eurycyde* only because the long and slender chelophores give it an aspect very different from that of any species of *Ascorhynchus*. It resembles *E. virago*, Loman, in having the insertion of the ovigers widely separated from that of the palps, but it differs in the dorsal spines of the body-somites and in the paucity of hairs on the body and limbs.

Nymphon andamanense, Calman.

Calman, 1923, p. 273, fig. 4.

Occurrence.—St. 45, S. Arabian Coast, 40 m., 2 spms.

Distribution.—Andaman Is.

Remarks.—The two specimens are probably males, although the genital pores could not be observed. They are larger than the holotype (length of trunk 4·2 mm.), and differ conspicuously from it in having the second free somite not longer than the first. Although the second tibia is longer than the first the difference is not so great as in the holotype. The terminal segment of the palp is distinctly shorter than the preceding. The chela has the fingers more curved, the teeth on them longer, and the palm less instead of more than two-thirds as long as the fingers. The setigerous cushion on the underside of the chela at the base of the immovable finger is more pronounced than in the holotype.

In all these points and in being irregularly sprinkled with minute spots of dark pigment, the specimens are intermediate between the holotype and Carpenter's *Nymphon maculatum* from the Red Sea. In the latter species, however, the neck is so greatly elongated and there are so many other differences of proportion that its distinctness from *N. andamanense* seems to be beyond doubt. If it be assumed that the elongation of the second free somite in the holotype of *N. andamanense* was an individual peculiarity, there seems no valid reason to forbid the reference of the present specimens to that species.

The spine formula of the ovigers is, in the larger specimen, 19, 12, 10, 11, and, in the smaller, 16, 12, 9, 10.

Nymphon foxi, Calman.

Calman, 1927, p. 403, fig. 102.

Occurrence.—St. 45, S. Arabian Coast, 40 m., 2 ♀, 1 juv.

Distribution.—Suez Canal.

Remarks.—The female specimens are about twice the size of the male type and differ from it in having the bi-papillate ocular tubercle a good deal taller, the chelophores with longer palm and shorter and more numerous teeth on the fingers ($\frac{26}{33}$ as against $\frac{13}{12}$), femur shorter than first tibia and less than three-fourths of second, main claw more than one-third of propodus and little longer than auxiliaries. The spines on the last four segments of the ovigers are 10, 8, 8, 10 as against 9, 9, 6, 7.

Nymphon arabicum, sp. n.

Occurrence.—St. 43, S. Arabian coast, 83 m., 3 ♂, 3 ♀. St. M.B. II*c*, S. Arabian coast, 29 m., 1 ♀.

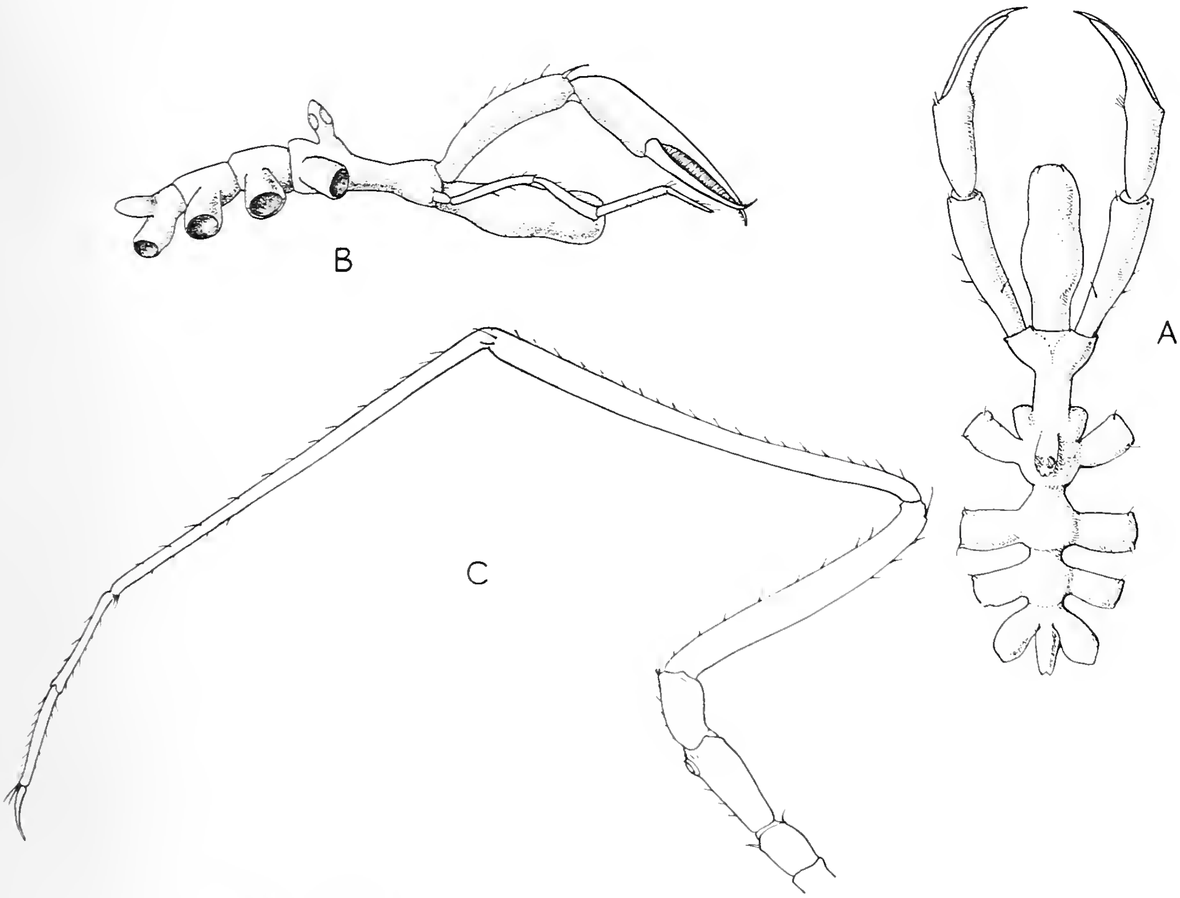
Description.—Body not very slender. Cephalic segment about half the length of the trunk; width at base of chelophores about $2\frac{1}{2}$ times diameter of neck. Lateral processes separated by intervals of more than half their diameter. Abdomen about as long as last pair of processes. Proboscis, from above, nearly as long as cephalic segment, with a distinct swelling about the middle of its length, where the diameter is greater than at either end. Ocular tubercle tall, with two apical papillæ close together. Eyes large, well defined.

Chelophores with hand as long as scape; palm twice as long as wide and two-thirds as long as fingers, which are curved and have close-set teeth, 64 on movable and 35 on immovable finger.

Palps slender, second segment little longer than third or fourth; fifth less than three-fourths of fourth.

Ovigers of male with distal process on fifth segment bearing setæ. Spine formula 15, 10, 9, 10.

Legs slender, not conspicuously hairy, second coxa twice as long as first and one-half longer than second. Femur two-thirds of first tibia, which is about equal to second. Tarsus slightly longer than propodus, which is about ten times as long as wide. Claw half as long as propodus and more than twice as long as auxiliaries.



TEXT-FIG. 3.—*Nymphon arabicum*, sp. n. A, Dorsal view of body with chelophores. B, Lateral view of body with chelophore and palp. C, Third leg of right side.

Measurements in mm.:

Length of proboscis (above)	1·75
,, trunk	3·0
,, abdomen	0·5
Second right leg:	
First coxa	0·6
Second ,,	1·25
Third ,,	0·8
Femur	3·6
First tibia	5·6
Second ,,	5·5
Tarsus	1·4
Propodus	1·2
Claw	0·6

REMARKS.—This species is clearly distinct from any hitherto described from the Indo-Pacific area. In the form of the chela it shows some resemblance to *N. pixellæ*, Scott (1912, p. 207), with which *N. solitarium*, Exline, is synonymous (1936, p. 414). In that species, however, the tarsus of the legs is at least twice as long as the propodus.

Callipallene pectinata* (Calman).

Pallene pectinata Calman, 1923, p. 275, fig. 5.

OCCURRENCE.—St. 45, S. Arabian coast, 40 m., 1 ♂. 3 ♀.

DISTRIBUTION.—Indian Seas, locality uncertain.

REMARKS.—The male specimen is a good deal larger than the holotype (trunk-length 1·3 mm.). The "neck" is more marked, although the relative length of the cephalic segment is much the same. The legs of the first pair are missing, but those of the second pair have the auxiliary claws with four, five or six teeth, those of the third with no teeth or one very minute, and those of the fourth pair with no teeth. Apparently the only other significant difference from the holotype is that the last two trunk somites are separated by a very distinct articulation. The spines of the ovigers are of the *Pallene* type, *i. e.* broadly ovate and finely toothed, and there is no terminal claw. The females have the neck rather shorter than in the male, and the teeth on the auxiliary claws are smaller and difficult to see. In one female the auxiliaries of the first legs have two or three teeth, those of the second three, those of the third two very minute, and those of the fourth are without teeth. In all cases the last two trunk-segments are separated.

Callipallene (?) *echinata*, n. sp.

OCCURRENCE.—St. 45, S. Arabian coast, 40 m., 1 ♂ carrying embryos.

DESCRIPTION.—*Trunk* short, the lateral processes well separated, the interval between second and third less than half their width; last two somites not separated by articulation. Cephalic somite about equal to rest of trunk; width in front greater than its length, and about twice the diameter of the short neck. Ocular tubercle taller than broad, obtusely pointed with conspicuous lateral papillæ; eyes well defined. *Proboscis* less than twice as long as wide, nearly cylindrical, bluntly rounded in front; surface hispid with short setæ. *Abdomen* about half as long as the trunk.

Chelophores short and stout; scape much shorter than the chela, each finger with eight large and rather closely-set teeth.

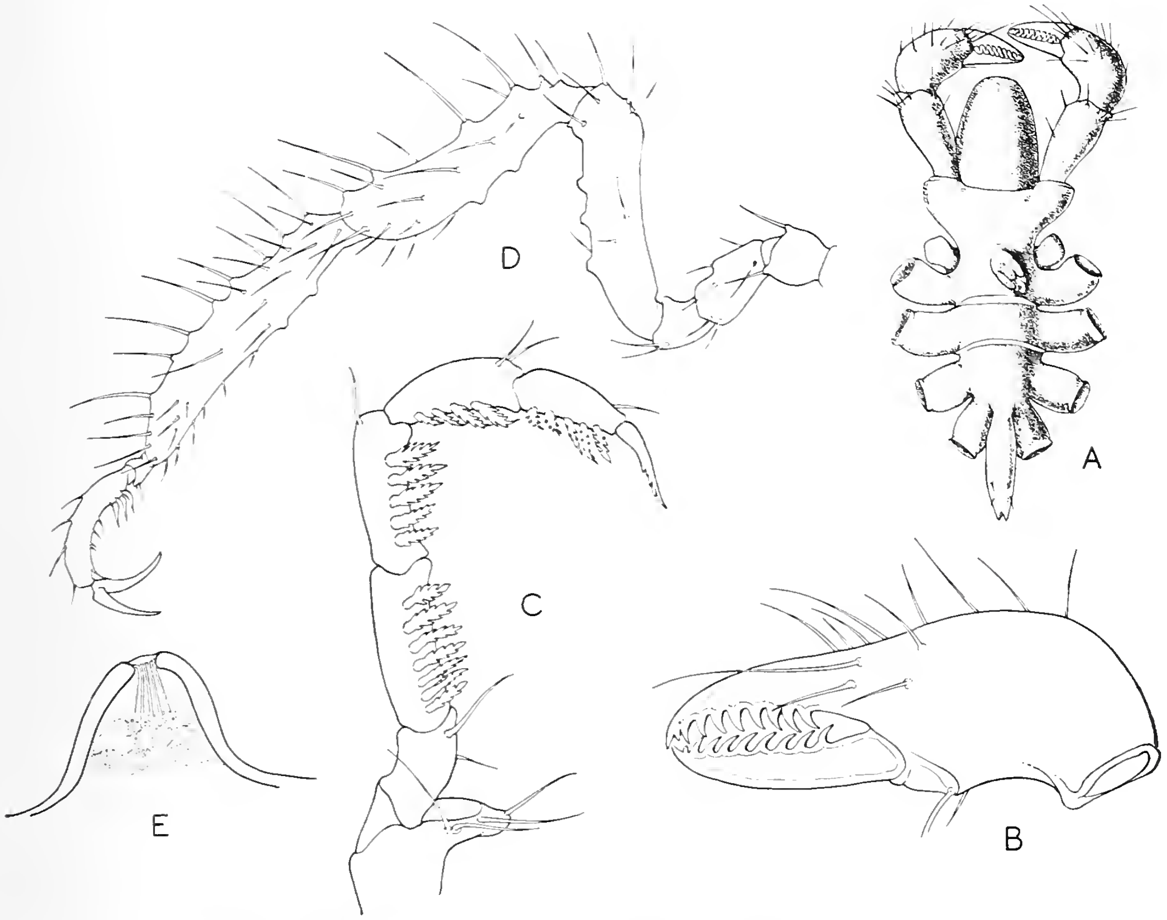
Ovigers with well-marked setigerous process at distal end of fifth segment. Spines of last four segments lanceolate, deeply and coarsely toothed; numbers 7, 5, 4, 5. Last segment with a strong curved pectinate claw.

Legs rather short, with the carpus and propodus much more slender than the preceding segments. Femur slightly shorter than first tibia and much shorter than second. Distal segments especially beset with strong, stiff setæ or spines mostly implanted on tubercular elevations. On the ventral surface of femur and both tibiæ is a row of truncated tubercles arranged as follows:

	Leg.			
	I.	II.	III.	IV.
Femur	4	3	3	3
Tibia I	2	3	2	1
Tibia II	2	2	2	2

* This name has been substituted for the preoccupied *Pallene* by Flynn (1929, p. 252).

These tubercles are hollowed distally where they are perforated by a number of minute pores, to which a bundle of fine ducts can be traced. These appear to correspond to the cribriform openings of the cement glands in *Phoxichilidium* and some species of *Anoplodactylus*.



TEXT-FIG. 4.—*Callipallene echinata*, sp. n. A, Dorsal view of body with chelophores. B, Chela. C, Terminal segments of oviger. D. Third leg of left side. E, Opening of cement gland on femur, further enlarged.

The propodus is curved, with three (or two) large spines proximally. The main claw is more than half as long as the propodus and the auxiliaries more than two-thirds as long as the main claw.

Measurements in mm.:

Length of proboscis (above) . .	0·35
,, trunk	0·95
,, abdomen . . .	0·42
,, cephalic segment . .	0·5
Width of cephalon . . .	0·55
,, neck	0·3

Third left leg:

First coxa	0·16
Second ,,	0·4
Third ,,	0·2
Femur	0·94
First tibia	1·0
Second ,,	1·13
Tarsus and propodus	0·46

Remarks.—This species differs in important points from all hitherto described in the Palleninæ, and its reference to the genus *Callipallene* is only provisional. In having the last two somites fused, auxiliary claws present, and the fingers of the chelophores toothed, it agrees with Loman's (1908, p. 42) diagnosis of *Pallene*, but in the coarsely denticulated spines of the oviger and the presence of a terminal claw it agrees with *Parapallene*, while in having no rudiments of the palps it differs from the group of aberrant species for which Loman provides no name.

If the truncated tubercles on the legs are rightly interpreted as marking the openings of the male cement glands, they differ in two important points from those of most Pycnogonida. They are found not only on the femur but also on the first and second tibiæ. In all Pycnogonida in which these glands have been described they are confined to the femur, with the single exception of *Parapallene hospitalis*, Loman, where they extend into the first tibia. Further, the openings of the glands are remarkable in being on the *ventral* surface of the legs. In most Pycnogonida the openings are on the dorsal surface, but Dohrn (1881, p. 199) describes the single opening in *Neopallene campanellæ* as ventral, and it is ventral also in at least some species of *Pallenopsis* (Calman, 1923, p. 281, fig. 8). It seems likely that the ventral position of the openings will furnish a character of some systematic value.

Parapallene longipes, sp. n.

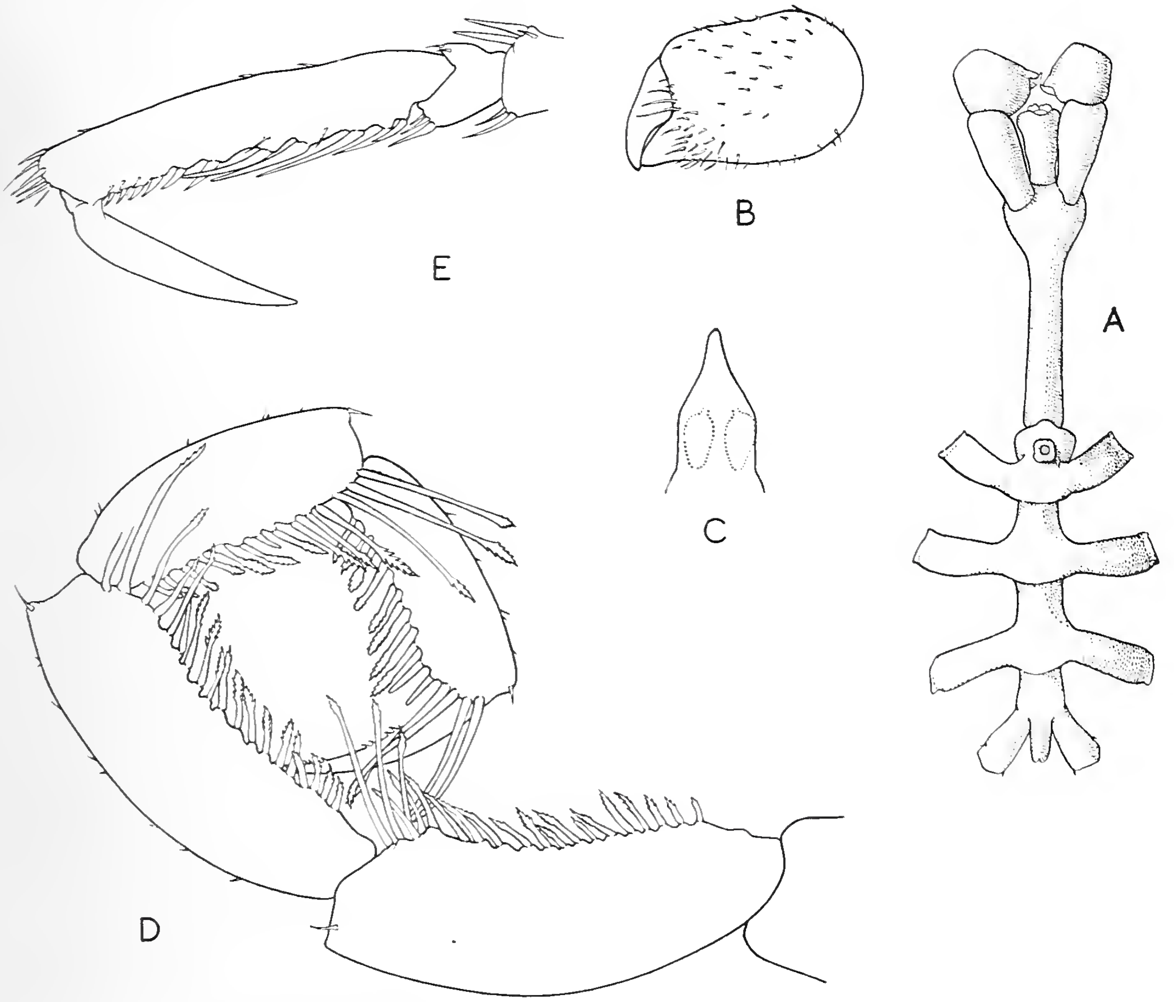
Occurrence.—St. 106, Zanzibar area, 183–194 m., 1 ♀.

Description.—*Body* slender and elongated; width between lateral processes not more than half the length of the latter, which are separated by at least twice their own diameter. Cephalic segment nearly half as long again as the rest of the trunk; width at base of chelophores two and a half times diameter of neck; neck defined by a fold of the exoskeleton which on the dorsal surface has all the appearance of an articulation, but on the ventral becomes merely a shallow groove; it lies just in front of the attachment of the ovigers and, on the dorsal surface, is obtusely angulated forwards. *Ocular tubercle* with rather tall, acute apex. *Proboscis* dilated at the tip; mouth small with projecting lips. *Abdomen* little more than half the length of last pair of lateral processes.

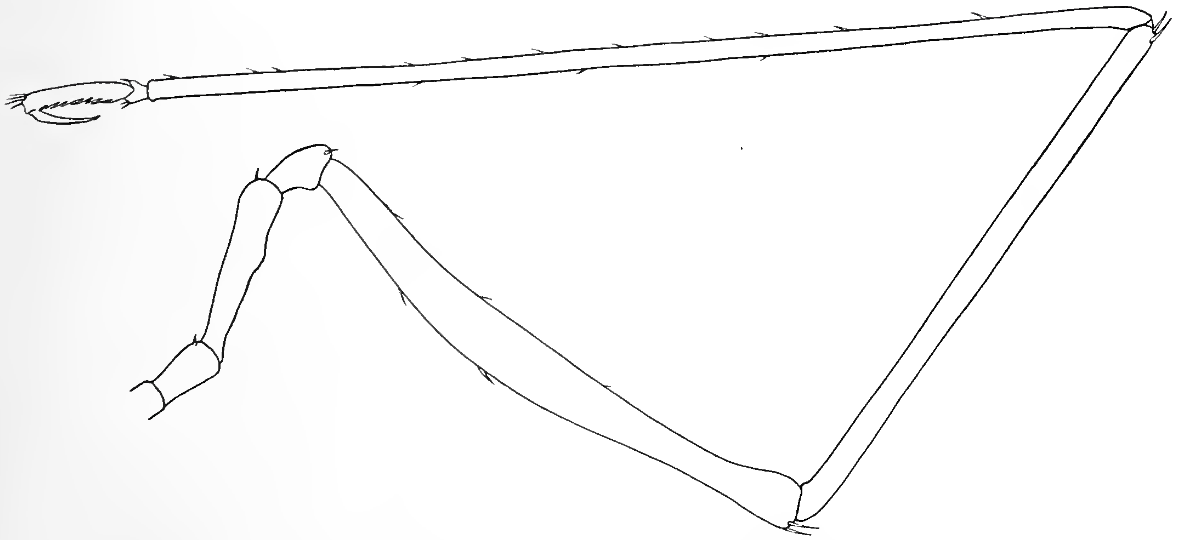
Chelophores with scape about twice as long as wide; chelæ inflated, hispid, fingers short, not toothed.

Ovigers with spines of terminal segments slender, narrowly lanceolate, finely serrated on both edges, becoming very long and slender distally on each segment; numbers 20, 19, 14, 14. Terminal claw finely pectinated on concave edge.

Legs very long, without spines or setæ on proximal segments, with few and scattered



Text-fig. 5.—*Parapallene longipes*, sp. n. a, Dorsal view of body with chelophores. b, Chela. c, Ocular tubercle from front. d, Terminal segments of oviger. e, Carpus and propodus of third leg.



Text-fig. 6.—*Parapallene longipes*, sp. n. Third leg of right side.

spines distally. First coxa longer than third and less than half as long as second. Femur and first tibia equal, second tibia about $1\frac{3}{4}$ as long. Propodus rather slender, claw two-thirds as long, no auxiliary claws.

Measurements in mm.:

Length of proboscis (above)	1·1
,, trunk	8·0
,, cephalic segment	4·75
Width at base of chelophores	1·5
,, of neck	0·65
Third right leg:	
First coxa	1·25
Second ,,	2·75
Third ,,	1·0
Femur	10·3
First tibia	10·5
Second ,,	17·2
Tarsus and propodus	2·0

REMARKS.—This species agrees with *Parapallene australiensis* (Hoek), the type of the genus, in all the characters regarded by Loman (1908, p. 42) as distinctive of *Parapallene*, and it may therefore be referred to that genus. It belongs to a group of species including, besides the genotype, *P. nierstraszi*, Loman, in which the neck is long and marked off behind by a fold of integument simulating a true articulation. Whatever the morphological significance of this fold may be (the first leg-bearing somite is not free from the head in any other Pycnogonid), Flynn (1928, p. 18) was in error in supposing there to be any difference in respect of this character between *P. australiensis* and *P. nierstraszi*.

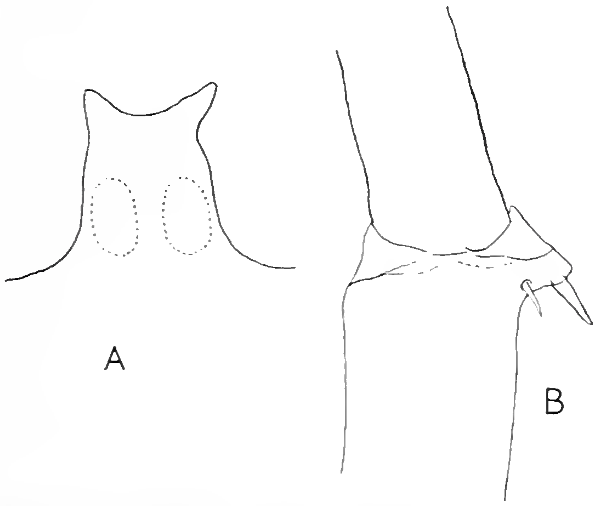
I have elsewhere (1937, p. 530) discussed the characters of *P. australiensis* and have described a new species, *P. challengeri*, which clearly belongs to the same group, but infringes the generic diagnosis by possessing auxiliary claws.

By the kindness of Prof. L. F. de Beaufort I have been allowed to borrow one of the syntypes of *P. nierstraszi* from the Zoological Museum, Amsterdam, and I give here some notes on it.

P. nierstraszi, Loman: Loman describes the four syntypes as females, but the one I have examined is, I think, undoubtedly a male. Like Loman I have been unable to detect the opening of the cement gland, but the genital apertures, although very minute and difficult to see, are present on the second coxæ of all the legs. More important, perhaps, as indicating the sex is the presence at the distal end of the fifth segment of the oviger of a distinct, though small, lateral process, bearing a large spine pointing obliquely backwards, flanked by two smaller ones (Text-fig. 7).

Loman's figure represents fairly well the general aspect of the specimen, but does not show clearly the spines on the body and legs. Each transverse process bears distally behind the middle of the dorsal surface a short spine set on a conical elevation; smaller spines are set in front of and behind it. The first coxa has three spines distally, the second coxa has two conspicuous spines near the base and it and the following three segments have each a distal group of stiff spines : the second tibia is spinous rather than hairy.

The ocular tubercle is described by Loman as having " zwischen den Augen eine feine konische Spitze ". In the specimen examined, however, it terminates in two prominent, well-separated, conical tubercles (Text-fig. 7). The spines on the ovigers are slender, finely serrated on both edges, increasing in length distally on each segment but not so markedly as in *P. longipes*. Formulæ 9, 10, 9, 9 and 11, 10, 8, 10.



TEXT-FIG. 7.—*Parapallene nierstraszi*, Loman. Syntype. A, Ocular tubercle from front. B, Junction of fifth and sixth segments of oviger.

Measurements in mm. :

Length of proboscis (above)	1·03
,, trunk	6·32
,, cephalic segment	3·5
Width at base of chelophores	1·0
,, of neck	0·4
Third left leg :	
First coxa	1·05
Second ,,	3·5
Third ,,	1·05
Femur	6·9
First tibia	6·9
Second ,,	8·8
Tarsus and propodus	1·5

It is possible, and indeed likely, that when further specimens are available for examination, the differences between the species mentioned will appear less marked, but for the present *P. longipes* may be distinguished from *P. australiensis* and *P. nierstraszi* by the much greater relative length of the legs and especially of the second tibia, and by the absence of conspicuous spines on the proximal segments of the legs and on the transverse processes. It is further distinguished from *P. nierstraszi* by the single apex of the ocular tubercle.

Pallenopsis brevidigitata, Möbius.

Möbius, 1902, p. 185, pl. xxvii, figs. 7–13 ; Flynn, 1928, p. 19, fig. 9.

Occurrence.—St. 107, Zanzibar area, 421–457 m., 1 ♂, ovig.

Distribution.—Off Dar-es-Salaam, 404 m., and off Natal, 46 fms.

Remarks.—The figures given by Möbius are clearly inaccurate in several particulars. For example the palp-rudiments are omitted from his Fig. 8, although they are described in the text as " kurz, kegelförmig, so lang wie breit ". Again, the auxiliary claws are omitted from Fig. 9 and they are not mentioned in the specific description, although they are included in the generic diagnosis on p. 184. Dr. A. Schellenberg has been good enough to re-examine the type-specimens, and to send me a sketch of the foot showing minute auxiliary claws as in Flynn's figure.

The segmentation of the *Trunk* is marked only by lines of colour with no perceptible grooving of the integument. The *Abdomen* extends only to about two-thirds of the length of the last lateral processes. The difference in size of the anterior and posterior eyes is hardly perceptible.

Chelophores.—Viewed from above the second segment of the peduncle is much more than half the length of the first.

Ovigers.—The sixth segment is dilated as described by Möbius.

Legs.—Third legs more than nine times as long as the trunk. Auxiliary claws very small, about one-seventh of length of main claw.

Endeis mollis (Carpenter).

Phoxichilus mollis, Carpenter, 1904, p. 182, plate, figs. 1–7.
Endeis mollis, Calman, 1923, p. 293, fig. 16.

Occurrence.—St. 45, off S. Arabia, 38 m., 1 ♂, 1 ♀. " Hydroid colonies " are mentioned among the contents of the dredge at this station, and it is to be presumed that the specimens of *Endeis* were feeding on these.

Distribution.—Muscat to Tonga Is. (Calman, 1923).

Remarks.—These specimens have the second tibia longer than the femur, the penultimate segment of the oviger expanded, the femur straight and its lateral spines inconspicuous and most of the other spines greatly reduced. In these characters they agree with most of the specimens which I have referred (*loc. cit.*) to Carpenter's species. They differ from them in the greater length of the proboscis, which in one specimen is equal to the body and in the other nearly so. The spine-bearing tubercles at the end of the femur are not prominent, and the cement glands are 30 in a single row. In the male the proboscis measures 3·2 mm., the body 3·6, and the third right leg 17·5 mm., the femur and the two tibiæ being 4·2, 3·9 and 4·9 mm. long respectively.

Achelia echinata, Hodge.

Ammothea (*Achelia*) *echinata*, Bouvier, 1923, p. 55.

Occurrence.—St. M.B.(*d*), Red Sea, 26 m., 1 ♀. St. 27, Gulf of Aden, 37–91 m. " In association with a finely branched Cœlenterate, apparently Antipatharian." 1 ♂.

Distribution.—Norway to Cape Verde Is., Mediterranean, New England coast.

Remarks.—The male from St. 27 measures 1·38 mm. in total length and shows all the characters enumerated by Bouvier as distinctive of this species. I have also compared it with specimens from the British coasts without finding any notable differences except that the palps seem to be relatively shorter in the present specimen.

The female from the Red Sea is minute (total length 0·8 mm.) and doubtless juvenile, but apparently belongs to the same species.

While recording these specimens under the name of Hodge's species, it should be pointed out that there are several species described from the Indo-Pacific region whose characters require further investigation. Ortmann's *Ach. echinata* var. *japonica* does not seem to be very closely related. Loman's *A. nana* from the Malay region is very similar to Hodge's species, but would appear to be distinguished by the very slender claws of the legs. In that species and in *A. aspera*, Loman, from Australia, the ocular tubercle is much shorter than in *A. echinata*.

Cilunculus sewelli, sp. n.

Occurrence.—St. 118. Zanzibar area, 1789 m., 1 ♀.

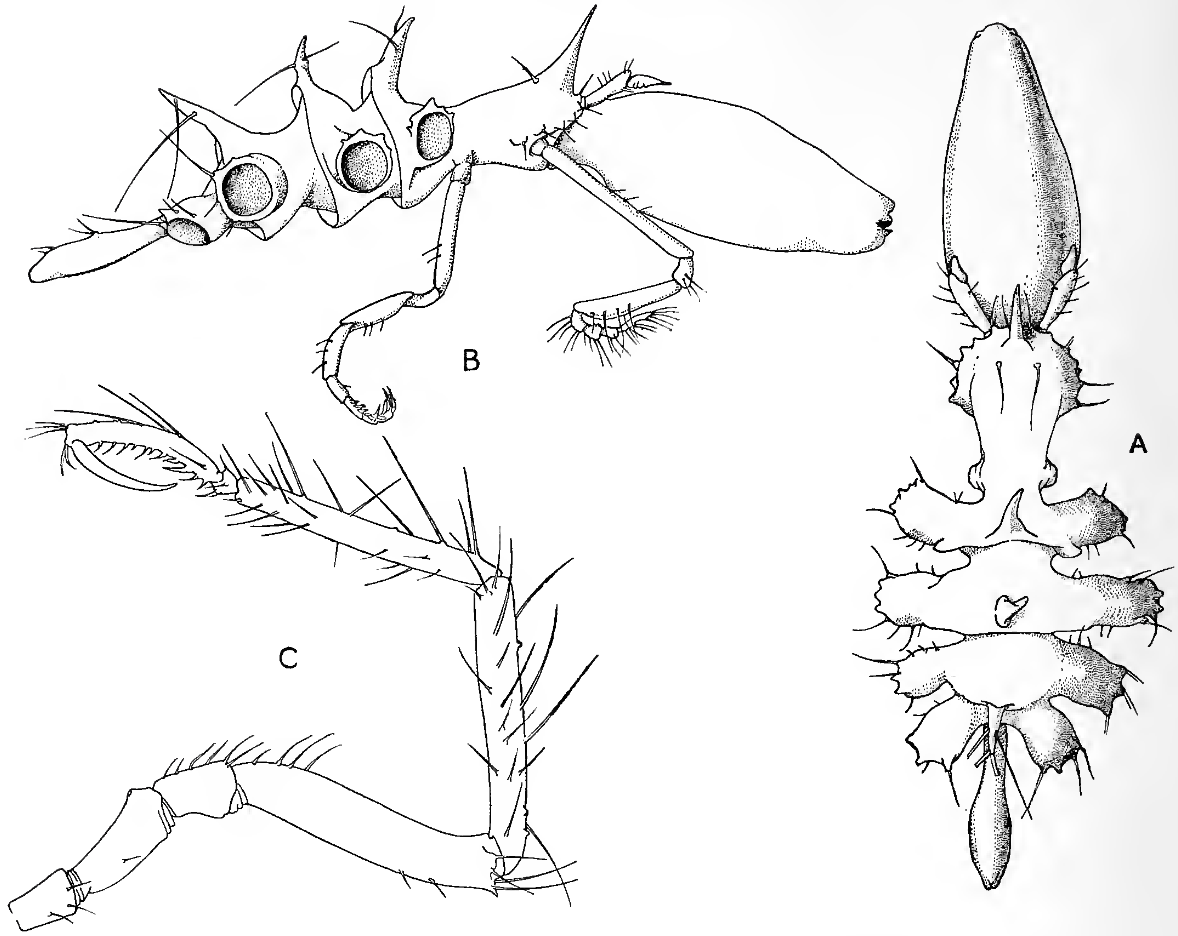
Description.—Body with scattered long hairs which become more numerous on the legs. *Trunk* distinctly and loosely articulated, the last three somites contracted in front of the lateral processes, then expanding to the anterior margin, which fits into the spacious articular cavity with everted edges of the somite in front (*cf.* Loman's *C. perspicax*, 1908, pl. vii, fig. 97). Cephalic somite longer than the three succeeding, expanded in front into a semicircular hood tuberculated on the margin and overhanging the bases of the chelipeds and palps; on the hind margin just in front of the everted edge a slender acute dorsal spine. Lateral processes each with three distal tubercles, the middle one the largest, each bearing a seta. Insertion of ovigers well in front of first lateral processes. Second and third somites each with a dorsal spine. The lateral processes are separated by less than their diameter, but the loose articulation of the somites suggests that a good deal of contraction should be allowed for. *Ocular tubercle* tall, slender, acute, just behind anterior margin; no eyes visible. *Proboscis* ovate, rather broadly rounded at the tip. *Abdomen* slightly clavate, less than half as long as trunk.

Chelipeds extending to less than one-third of length of proboscis; scape of two segments, the first very short and hidden by the hood. Chela acutely pointed and slightly curved distally. Movable finger represented by a small spike.

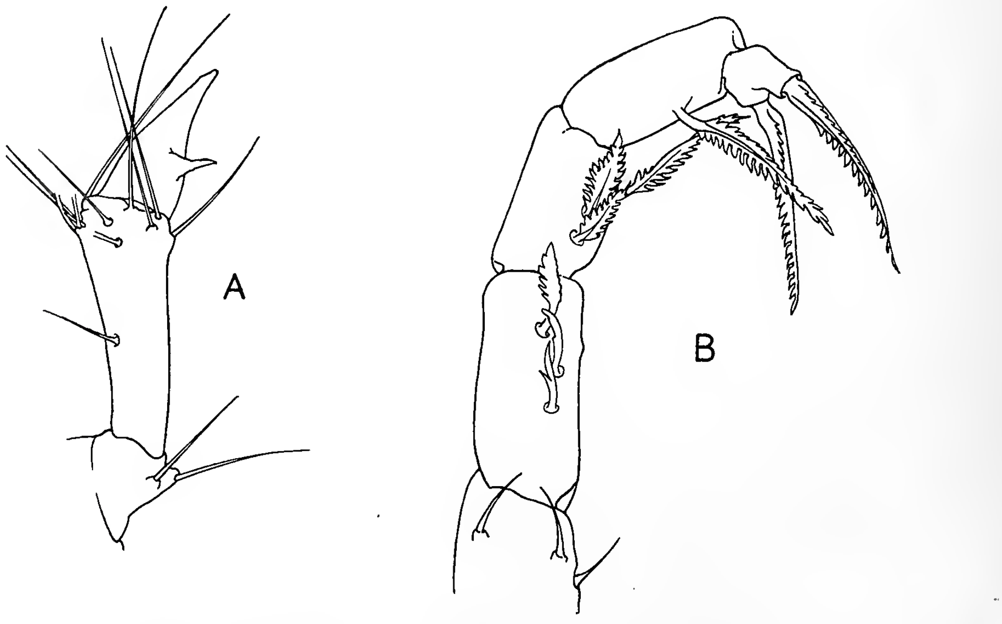
Palps doubly geniculate, of nine segments, the fourth slightly inflated, a little more than half as long as second; last five short, expanding distally on ventral side, so as to give a slightly serrate edge to this part of the palp.

Oviger rather short and slender, of ten segments. Terminal segment very minute, without claw, with two large serrate spines; ninth segment with one spine, eighth and seventh segments with three spines each.

Legs moderately slender, femora little dilated. The three coxæ together, the femur, and the first and second tibiæ subequal. Propodus about five-eighths of second tibia; claw curved, about three-quarters of propodus; auxiliaries about one-quarter of main claw. The legs of the first pair are missing, but genital openings are present on all the other pairs.



TEXT-FIG. 8.—*Cilunculus sewelli*, sp. n. A, Dorsal view of body with chelophores. B, Lateral view of body with chelophore, palp and oviger. C, Third leg of right side.



TEXT-FIG. 9.—*Cilunculus sewelli*, sp. n. A, Chelophore. B, Terminal segments of oviger.

Measurements in mm.:

Length of proboscis (above)	3·3
,, trunk	3·6
,, abdomen	1·5
Width across second lateral processes	2·7
Third right leg:	
First coxa	0·8
Second ,,	1·1
Third ,,	0·8
Femur	2·7
First tibia	2·7
Second ,,	2·7
Tarsus and propodus	1·8

REMARKS.—This species seems to be undoubtedly congeneric with Ortmann's *Parazetes pubescens* (1890), which Loman (1911) identifies with Böhm's *Lecythorhynchus armatus* and refers to his own genus *Cilunculus*, of which one of the leading characters is the growing forward of the anterior margin of the head " wie ein Schutzdach über die kleinen Cheliforen ". Loman describes and figures the chelophores as having an unsegmented scape, although Böhm mentions and Ortmann clearly figures the short spinose basal segment. Böhm's species has the anterior " hood " produced into two long spiniform processes, and among other characters distinguishing it from the present species it has the auxiliary claws some two-thirds as long as the main claw.

Pycnogonum africanum, sp. n.

OCCURRENCE.—St. 106, near Zanzibar, 183–194 m., 1 ♀ (holotype). St. 119, near Zanzibar, 1228 m., 1 ♀ (paratype).

DESCRIPTION OF HOLOTYPE.—Integument brown, shagreened with minute granules, some of which are tipped with spines; marked with reticulate tracts of darker colour forming a definite pattern on the body and less conspicuously on the legs.

Trunk with three transverse ridges each with a tall, slender median spine. Lateral processes distinctly separated, each with three distal tubercles, the middle one spiniform. Cephalic segment a little longer than the two following somites together; front margin overhanging base of proboscis as a collar. Width across first and second lateral processes about equal. Ocular tubercle taller than wide, bluntly conical; eyes distinct but not pigmented.

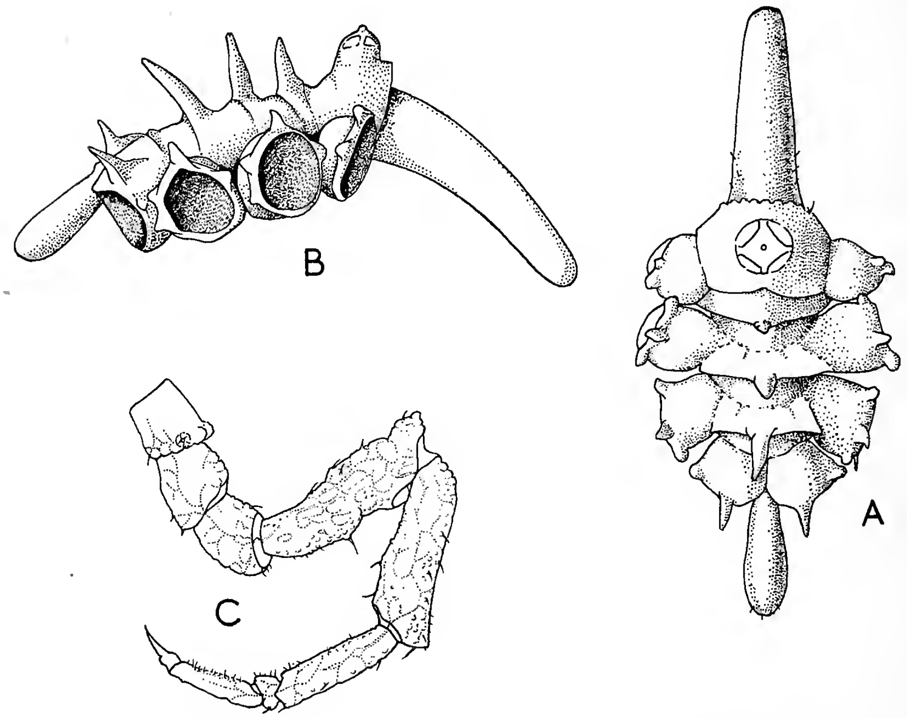
Proboscis rather slender, decurved, narrowing gently to blunt, rounded tip.

Abdomen subcylindrical, nearly reaching distal end of second coxa of last leg.

Legs with first coxa not twice as wide as long, with two tubercles on posterior half of distal margin. Femur with a distal projection bifurcated at the tip. Second tibia a good deal more slender than the first. Third right leg nearly three times as long as the trunk.

Measurements of holotype in mm.:

Length of proboscis	3·2
Width of proboscis at base	0·96
Length of trunk	3·58
,, abdomen	1·37
Third right leg:	
First coxa	0·7
Second ,,	0·95
Third ,,	0·6
Femur	2·1
First tibia	2·0
Second ,,	1·5
Tarsus and propodus	1·45
Claw	0·6



Text-fig. 10.—*Pycnogonum africanum*, sp. n. a, Dorsal view of body. b, Lateral view of body. c, Third leg of right side.

Description of Paratype.—Integument pale, its texture resembling that of holotype. *Trunk* having the first dorsal ridge with only a low tubercle, second with a taller acute process, third with a long, slender spine. Lateral processes without distinct tubercles. Ocular tubercle produced above the indistinct eyes into a tall acute spine. *Abdomen* slightly surpassing second coxa of last leg. *Legs* with femur distally produced into a shorter anterior and a longer posterior tubercle. First tibia with two subequal distal prominences.

Measurements of paratype in mm.:

Length of proboscis	2·5
,, trunk	3·2
,, abdomen	1·3
Third right leg:	
Total length	9·4

REMARKS.—The distinction between "téguments chagrinés" and "téguments réticulées" on which Bouvier (1922, p. 113) bases his primary division of the species of *Pycnogonum* (and of *Pentapycnon*) is not absolute. Flynn (1919, p. 92) has already described in *P. aurilineatum* a "shagreened" species showing traces of reticulation. In Flynn's species, however, as in that now described, the network is less conspicuous than it is in the species of Bouvier's "reticulated" group.

Assuming that this species falls into the division A of Bouvier's key, then in having the legs not conspicuously tuberculated, the proboscis a truncate cone, the abdomen bluntly rounded posteriorly and dorsal tubercles on the body, it approaches *P. crassirostre*, Sars, and *P. occa*, Loman. The tall and acute dorsal tubercles and the slender decurved proboscis separate it from the former. With the latter the resemblance is closer, but the wide separation of the lateral processes, the distinctly clavate abdomen and the much longer claw on the legs sufficiently distinguish Loman's species.

The paratype from St. 119, although only a little smaller than that from St. 106, appears to be more immature since no genital apertures could be observed. Possibly attributable to this immaturity are the tall, acute, ocular tubercle (as in young *Achelia*) and the distal processes on the femur and first tibia. The only remaining character distinguishing it from the holotype is the reduction of the first median dorsal process of the body.

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SCIENTIFIC REPORTS

VOLUME V, No. 7

THE FLABELLID AND TURBINOLID CORALS

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WITH SEVEN PLATES AND SIX TEXT-FIGURES

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THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
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[*Issued* [illegible] *July*, 1938]

DESIGNED AND
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21, HART STREET, W.C.
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Made and printed in Great Britain

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CONTENTS.

I. PREFACE.

The collection of corals obtained by the John Murray Expedition only differs from that of most former expeditions in that it will be possible subsequently to determine with some accuracy the nature of the ground, on which the corals dwelt, and the character of the water, from which they obtained their food. It will be seen that the collection now described contains relatively few species. This is largely due to the fact that dredge, trawl or grab, when it reached the deck, if it contained any corals at all, was found usually to have captured a large number generally of one or a very few species. There were different stages of growth, though in most cases the majority were adult. A study of such a series enables the worker to determine the variation of the species in all its characters. These corals all show great vegetative variation, but yet there would seem to be groups of individuals which are gametically separated from all other groups. The recognition of

* Miss Waugh made an extensive examination of the following genera, tabulating and measuring every specimen : *Stephanocyathus, Paracyathus* and *Deltocyathus*.

vegetative variations is, of course, inimical to species-formation by authors, unless, as Cuvier is stated to have done, embarrassing specimens are destroyed. Species founded on single, very few or dead specimens, chemically altered, had better be ignored unless available for re-examination, for which they might be lent as the Director of the Museum at Oslo lent us the unique *Fungiacyathus* of Sars. The Director of the British Museum was also as helpful as his rules allow, but "types" are not lent; it would be to the advantage of science if he and his Keepers could be given discretion in this matter. In particular, we desired to see Duncan's types, but numerous inquiries both in England and in the United States gave us no information as to their whereabouts.* Unlabelled specimens and drawings in old plates are valueless for the identification of species.

II. INTRODUCTION.

The old family Turbinolidæ form a group of solitary corals extending from the Lias to the present day. Most genera and species are fossil—and most species are founded on single or few specimens. Of living species, we are generally informed that they were collected at a certain depth by an expedition; occasionally we know the nature of the bottom on which they were living, but this is exceptional. With fossil forms it is rare to find any attempt to reconstruct their former environment. The chief home of the group to-day is at a depth greater than 50 fathoms, but at times species may be found in shallower waters—and one genus, *Heterocyathus*, which is usually associated with an *Aspidosiphon*, is essentially a shallow-water form. As to temperature the main fall is at about 50 fathoms, and, if there is any restriction here, it is one of higher temperature. Lastly, there is no association of these corals with symbiotic algæ as yet definitely known.†

To determine genera there is shape, discoid or upright, calicle round, oval or compressed, with base any size between a point and a broad base of attachment, this and the whole column even having a breadth equal to that of the calicle; lastly, the whole coral sometimes free or unattached. The wall may be a true epitheca, formed from inside by coral deposition outside the polyp-wall, this character giving the family Flabellidæ.‡ For the rest, in the Turbinolidæ the wall is a theca formed by depositions between neighbouring septa, these meeting and fusing; the plate outside this wall is termed the costa and that inside the septum. It follows that costæ are always present with a thecal wall, but the polyp in its retreat up the outside of the coral skeleton may fill in the spaces between neighbouring costæ, as it were continuing its basal plate up the sides of the coral; the corallum thus deposited has a tendency to be rather shiny and is epithecal.

The edges of septa and costæ may end in teeth and an inner tooth of a septum may be large, perhaps elongated, the whole somewhat thickened. Often a circle of columns lies in front of certain septa, only connected to the same by later formed, thin trabeculæ of corallum and not parts of the septa; these are sometimes hard to distinguish from septal teeth and are the pali.

If pali are present, there is usually a columella, but the reverse is not the case. The presence or absence of pali and columella are generic characters, and often the character

* This is particularly unfortunate in respect to *Conocyathus*, for it is on Duncan's authority that this is to be recognized as a living genus (*vide* 'Proc. Zool. Soc.' 1876, 431).

† *Cp.* 'Brit. Mus., Terra Nova Exp.' V, 129 (1929).

‡ *Cp.* Vaughan, 'U.S. Nat. Mus.,' Bull. 59, 48 (1907).

of the columella is also important, a single or several rods, a plate, twisted ribbons or merely processes of corallum arising from the base and joined below to the septal ends, forming by fusion together a kind of spongework. In all cases, deep down in the corallum, septa, pali and columella are usually connected by trabeculæ, narrow threads of corallum of later formation.

The septa in all cases appear to arise as a circle of six vertical plates, then a further 6, 12, 24, etc., and thus cycles I, II, III, IV, etc. Three to five cycles usually form the regular number, 24, 48 and 96 septa, but different numbers are found within many genera, so that they are of little use in the classification of genera—and the same remark applies to the number of pali, which may lie before I, II, III or IV, often before two of these. Generally 6 (I) or 12 (I and II) septa are broader, thicker and rise higher than others, and commonly between them lie three septa (II and two of III, or III and two of IV), so that the septal system seems in groups of 4. The extraordinarily uniform commencing group of 6 is often disturbed in later life, especially in compressed calicles, where there is need for more groups of 4, the septa of each group and of the groups themselves being equidistant from one another. Thus may appear septa characterized, in the terms of the above hexamery, as belonging to a cycle not usually present, whereas in reality it is generally the formation of an additional 4-group; here pali also form before the appropriate septa. In a compressed calicle, if more 4-groups are wanted, there should be 2 at each end—and this is frequently the case where the largest septa number 12, thus giving 16 septa, to which may be added pali of equal number, if pali are present in the species. This is especially well marked in *Caryophyllia*, but here there is one little compressed species below* with 8 larger septa and pali, whereas there ought to be 10 if two groups of 4 are added symmetrically. Ten septa is a common phase in growth-number, the different cycles of septa arising at different heights within the coral as it grows upwards, but it is never an adult feature, while 8 is not rare.

Of specific characters, other than those referred to above, there are few of value. Indeed, corals especially, and to some degree all true, fixed, sedentary animals, are unhappy in this respect. Their feeding is mechanical, swallowing aided by tentacles and peristome forcing the food into the stomodæum and ciliary currents leading into the same. They further have no power of movement. Thus are eliminated all organs of feeding and movement, which so greatly aid in specific identification in free-living animals, which have the power of choosing their food and the means of finding it.

Then there is the shape, whether free or fixed, cone or broad base, or a disc—this often generic. It will be seen later that in *Deltocyathus* we think the coralla never were fixed,† the whole skeleton growing within the polyp, thus differing from *Fungia*, the mode of dehiscence of which pervades all ideas of discoid corals. In many cases the original point of attachment was minute, and the freedom later attained is frequently due to upright growth and a subsequent detachment due to the mechanical factor of weight. Where the coral is attached to rock it grows at right angles to the same, and where free it desires apparently to present its mouth and oral disc parallel to the bottom, thus escaping mud and rising above the motionless layer of water—a possible exception here being *Flabellum*. A disc is easy, but an upright coral can only attain this position by growing in a curve if it becomes free; in this respect our series of free-living species of

* *Vide C. mabahithi* n. sp., p. 178.

† *Vide* p. 195.

*Caryophyllia,** all lying on muddy grounds, is important. However, we may be indulging in a false generalization.

If polyps of a reef-living species of coral are damaged, almost the smallest part will regenerate the polyp and hence its corallum. The forms, however, that one of us experimented with at Minikoi were mostly colonial, which introduces a complication, but *Fungia* regenerated well, though requiring a reasonable piece, preferably a sector from its centre. Here, in our collection, are many examples of regeneration, and we are led to the opinion that one group of the "colonial" Turbinolidæ are really due to a peculiar form of this (*vide* p. 182). Upright growing coralla often show breakages and regeneration of parts, outgrowths which give rise to new calicles, perhaps inside the original calicles. Thus almost any shape may result, but the regenerated corallum always tries to assume the shape characteristic of its genus (*cp. Tropidocyathus nascornatus* n. sp., p. 193). In all the above the need for regeneration may be caused by an accident, but in the species referred to this seems impossible. In some discoid corals of which the discoid *Diaseris*-group of *Fungia* has been especially studied, this is clearly not the case.† Nor can it be deemed to be in *Fungiacyathus* and perhaps other forms.

These considerations all point to the need for a revision of these solitary corals. Vaughan and Wells circulated a list of genera of Turbinolidæ some years ago showing their ideas as to these. We trust that some day they will publish their views. Only thus by a combination of specialization in and study of living and fossil forms together, such as these authors offer, can any measure of finality be attained. The student of living forms is confronted with chemical changes which are embarrassing, viz. a possible change from aragonite to calcite, and always a certain thickening of septa and all parts of the skeleton by an opaque surface deposition of calcium carbonate, a phenomenon common also in living corals after death. Further, epitheca is ill-defined between geologists and zoologists, the latter regarding the epitheca, of which the basal disc is part in development, as deposited from one side (the inner side) only, whereas all other parts grow up with corallum being deposited on both sides.‡

III. ON GENERA FROM THE WEST INDIES.

Dr. Thomas Barbour, Director of Agassiz Museum, Harvard, most generously sent us specimens of many of the species of corals described by Count L. F. de Pourtalès and described in the publications of his Museum. One series arrived in England about the middle of April, 1937, and was delivered five months later, meantime lost in the custody of the British Customs. Informing Dr. Barbour, he sent us a further consignment, which has proved invaluable when added to the first, allowing us to make a more certain examination of the genera and species. These specimens, when belonging to species of

* *Vide* pp. 173 *et seq.*

† *Cp.* Gardiner, 'Trans. Linn. Soc.' 2nd ser., xii, 257 (1908).

‡ We have not found in the Murray Collection three Malayan genera described by Alcock in the "Siboga" Report, pp. 12, 21 and 33, viz. *Lochmæotrochus*, which is a compound *Conotrochus* (Flabellidæ), *Citharocyathus*, on which we express no opinion, and *Placotrochides*, founded on two dead and decayed coralla, suggesting to us similarly decayed *Caryophyllia*. Bourne ('Trans. R. Soc.,' Suppl. Vol. 1905, p. 191) has *Rhodocyathus* and *Cyathotrochus*, each founded on a single specimen, which have obvious relationships to *Stephanocyathus* and *Trochocyathus*. All these genera, except perhaps the first, require further examination before being accepted as good; this remark also applies to *Aulocyathus* von Marenzeller ("Valdivia" Exp., p. 300, 1904) from the E. African coast, 400 and 463 m.

well-known genera, may be found referred to in our systematic section, but an examination of some genera follows; they are added to the British Museum collections.

*Schizocyathus** is represented by a cone-shaped calicle, about 3 mm. high by 2·5 mm. diameter of mouth and 1 mm. at its broken and open end, together with 6 sectors of a broken-up stem varying up to 15 mm. long. The calicle internally has 6 radial divisions, each consisting of 2 septa uniting in front of a third, which is larger, as shown in the figures; between these are spaces with tiny septa, termed " primary " and " rudimentary " by Pourtalès. With a rather thinner wall outside these divisions, it is easy to see how the long stem may split up into sectors (6), and our pieces show similarly two rows of dots corresponding to their interseptal chambers. Lindstrom supplies an admirable description of the wall of the calicle: " The epitheca of the West Indian specimens is glossy, very finely striated by minute transverse lines, which are crossed by equally fine, longitudinal striæ." Further, " there exists no wall as a separate formation, distinct from the epitheca ". With this conclusion we agree, placing the genus in the Flabellidæ.

The reference of *Turbinolia* (Lam.) to the Turbinolidæ, apparently accepted by all authors, appears to us highly doubtful in view of our examination of two of Pourtalès' specimens of his *T. corbicula*,† which presumably were recently alive, but which were dead and so damaged as to cause the suggestion that they were " perhaps fossil (?) ". Edwards and Haime‡ remark, " chaque sillon intercostal présente une double série des tres petites fossettes ", which is made understandable by their illustrations in British ' Fossil Corals ' (plates ii, iii). Pourtalès' description and figure of *corbicula* are correct, but in our opinion these " fossettes " perforate the theca and thus suggest for the genus an alliance with a different section of corals.

Thecocyathus Ed. & H.§ is defined on three fossil species as possessing " une epitheque complete ". Pourtalès‖ referred to it two living species, *T. cylindraceus* and *lævigatus*, specimens of which are before us. There is no reference to any theca, and we cannot find such in our specimens, although the outer parts of the septa, close under the epitheca, thicken and so become fused to one another. Alcock, of his species *cinticulatus*,¶ says that the calicle " is smothered in an epitheca so thick and copious that the edge of the calyx which just shows clear of it has a strangled and swollen look ". There are no polyp tissues to protect this epitheca externally, while within there is a deposition of corallum. In specimens which one of us (J. S. G.) has examined the surface is covered with worm-tubes and borings penetrate; as the interseptal parts decay more freely the septal edges (" costæ ") project. In this connection the descriptions of Alcock's *rhombocolumna* and *virgatus*** may be examined. Clearly, according to the definition of Flabellidæ the genus *Thecocyathus* should be placed in this family.

Leptocyathus as a living genus depends on Pourtalès†† and Lindstrom.‡‡ Edwards

* Pourtalès in ' Hassler Exp., Corals ', 36, vi, 12, 13 (1874), and Lindstrom, ' K. Vet. Ak.' XIV, 15, with text-figs. (1877).

† ' Bull. Mus. Comp. Zool.' V, 203, i, 12, 13 (1879).

‡ ' Cor.' II, 60 (1860).

§ ' Cor.' II, 48 (1860).

‖ ' Cat. Mus. Comp. Zool.' 13, ii, 14, 15, v, 3, 4 (1871).

¶ ' " Investigator " Report,' 17, ii, 5, 5*a* (1898).

** ' Siboga Exp.' 16, ii, 12, 13 (1902).

†† ' Cat. Mus. Comp. Zool.' 12, iii, 1–3 (1871).

‡‡ ' K. Sven. Ak.' XIV, 9, i, 5–9 (1877).

and Haime* in their table separate *Leptocyathus* from *Deltocyathus* by its pali existing before all cycles of septa. Three Pourtalès' specimens of his *L. stimpsoni* we should without hesitation have placed in the genus *Deltocyathus* as undoubtedly Edwards and Haime would have done, its pali agreeing. Two of the specimens have regenerated from sectors of discs, as shown in one of Pourtalès' figures, which do not show the fusion of costæ described by the author, nor that of the septa mentioned by Lindstrom.

The specimen of *Stenocyathus* Pourtalès† before us is 24 mm. long by 3 mm. across its open calicle and nearly 2·5 mm. at its broken end; it is somewhat curved. The calicle shows the characteristic central columella-rod surrounded by rods of 6 pali, and this arrangement is clearly visible at the opposite end, although the seven rods tend to fuse in the centre; the interseptal spaces are wide open. The lower half of the corallum is somewhat decayed externally. The costæ, which should show clearest immediately below the mouth of the calicle, where they should be covered by the edge-zone, are not visible here, but have become well established 3–4 mm. below. Here are transverse growth markings, such as shown in Pourtalès' figure (iii, 11). Until the relations of the polyp and corallum are determined, we cannot agree that this genus is correctly placed in the Turbinolidæ, believing its wall to be an epitheca, the costal appearance secondary, due to the decay of the epitheca, between the outer edges of the septa.‡

Specimens of *Anthemiphyllia* Pourtalès are very beautiful, especially in their well-defined theca and the thin, transparent, porcellaneous epitheca which is attached to the external ends of the septa, viz. costæ, as in *Antillia*. The septa are in two series, the larger extending to the shallow central columellar space, the smaller only clearly visible on the rim of the saucer. The broad, flattened spines on the septal edges are arranged in concentric circles around the columellar space, which is about one-third the diameter of the calicle. The columella is a rather solid, flattened mass of processes, between which there is much secondary filling in by corallum; further, there is a closing-in of the central parts by "half floors or shelves" (Pourtalès). We prefer Pourtalès' suggestions that this genus is related to *Antillia*, *Montlivaultia*, etc., and we regard it as one of the solitary Astræidæ.

A small specimen of *Guynia annulata* Duncan from the Hassler Expedition would unhesitatingly be placed by us in the Flabellidæ, the 4-system of septa being found occasionally in many genera. Surely *Pyrophyllia* Hickson§ might reasonably be regarded as a synonym of *Guynia*.

We have been lent by the Agassiz Museum what we believe to be the type and figured specimen of *Parasmilia variegata* Pourtalès.‖ This species, together with *P. lymani* Pourt.,‖ was placed by its author in a new genus *Dasmosmilia*,¶ with figures of new and perfect specimens from a new locality. It is stated in the original description, "dissepiments not observed, none in the upper three-fourths of the corallum", and, with the specimen before us, we see no reason to believe that they are present and to place the

* 'Cor.' II, 10 (1860).

† *Vide* 'Cat. Mus. Comp. Zool.' Harvard, IV, 9, i, 1 (*non* 2), iii, 11–13 (1871); 'Bull. Mus. Comp. Zool.' VI, 101, i, 15, 16 (1880).

‡ We cannot explain Pourtalès' Pl. iii, fig. 13, for we can find nothing similar. Lindstrom ('K. Sven. Ak.' XIV, 19, 1877) had not in our opinion a species of *Stenocyathus* Pourtalès.

§ 'Mem. Lit. Phil. Soc.' Manchester, LIV, No. 12 (1910).

‖ 'Cat. Mus. Comp. Zool. Harvard,' XXI, 20, i, 13 (1871).

¶ 'Bull. Mus. Comp. Zool.' VI, 108, ii, 11, 12 (1880).

genus in the Astræidæ. Dissepiments are not visible in some specimens of *D. lymani* before us, likewise from the Agassiz Museum: here Pourtalès called them "rudimentary, membraniform, nearly horizontal". The specimen of *D. variegata* has ragged, inner parts of the septa, which appear to us paliform, while the columella has a number of upstanding small rods on a trabecular mass joining the septa together in the centre of the calicle. We suggest that *Dasmosmilia* is a turbinolid, and that *D. variegata* may prove to be synonymous with *Tropidocyathus nascornatus* below. It certainly has the same biological characters of splitting and regeneration, but the coloration is described as different, though there is no colour in one of the two specimens before us (apparently the figured type), while traces of its supposed purple septa should persist. Two specimens of *D. lymani* have grown on sectors of coral of the same genus, but it is impossible to tell whether this is regeneration or the settlement of ova: one has two young corals growing out in its dead calicle.

IV. FLABELLIDÆ.

The corals with living species placed in this family include *Flabellum* (syn. *Rhizotrochus*, *Blastotrochus* and now *Ulocyathus*), *Placotrochus*,* *Haplophyllia* (syn. *Duncania*, *Vaughanella* and *Gardineria*), and *Conotrochus*, to which, from our examination of West Indian corals above, we suggest the additions of *Thecocyathus*, *Stenocyathus*, *Schizocyathus* and *Guynia* (syn. *Pyrophyllia*).† The critical character, separating the family from Turbinolidæ, is that the polyp has no edge-zone, hence does not extend outside the calicular wall, which is accordingly formed by an epitheca.‡

Employing this definition, *Conotrochus* belongs to this family, for its only wall is epithecal. After a coral has defined itself in its growth and reached maturity, when growth in size slows down as in all animals, an additional deposition of corallum may take place underneath the polyp tissues, where the skeleton is formed, viz. under the calicoblastic ectoderm, but may be specialized to certain parts. This is clearly seen within the external epitheca in many species of *Flabellum* and is especially the case in *Conotrochus*. We suggest that it is mainly a physiological character, concerned primarily with the rate of metabolism and is not comparable to that filling-up and strengthening of the whole corallum in its interseptal spaces by dissepiments and otherwise, so characteristic of the Astræidæ.

Genus *Flabellum*.

The genus *Ulocyathus* M. Sars§ is described at great length. "La surface extérieure du calice et la base sont nues sans aucune membrane couvrante" shows that this genus must be regarded as synonym of *Flabellum* (Lesson)—a conclusion amply supported by the whole description in spite of a reference to outer ridges, which are termed "costæ".

* *Vide* Bourne, 'Trans. Roy. Soc.,' Suppl. Vol., 1905, 200, i, 5. See also his definitions of the families, pp. 189 and 195.

† *Vide* p. 172.

‡ The astræid, *Antillia*, has both epithecal and thecal walls, but there are no Flabellidæ showing these characters.

§ 'Fauna Litt. Norvegicæ,' XI, 73–9, x, 18–27 (1856).

Flabellum pavoninum (Lesson).

For literature and synonymy see Gardiner, 'Marine Invest. in S. Africa', II, 123 (1902), and 'Records Indian Mus.' XXXI, 301 (1929).*

St. 89, 193 m., s. sh. r., 1 dead.
St. 104, 207 m., gr. gy. s. m. sh., 1 dead.
St. 106, 183–94 m., gn. m., 6 living and 28 dead.
St. 123, 256–366 m., gn. m. s. r., 1 living and 1 dead.
St. 149, 238 m., cr. r. lth., 1 dead.
St. 157, 229 m., cr. r., 1 living and 3 dead.

An examination of one polyp assured us that this is the South African species. Evidently a widely distributed species of moderately shallow waters, with *F. rubrum.*

Flabellum rubrum (Q. et G.).

For literature and synonymy see the same references as under *F. pavoninum.* The species was similarly checked by a polyp.

St. 45, 38 m., lith., 1 living.
St. 89, 193 m., s. sh. r., 2 dead.
St. 106, 183–94 m., gn. m., 3 living, 7 dead.
St. 149, 238 m., cr. r. lith., 2 dead.
St. 209, 366 m., gr. br. m. r., 7 dead.

Some of these specimens might be referred to *F. stokesi* Ed. & H., which we do not regard as a gametic species or variety of *F. rubrum.*

Flabellum (*Rhizotrochus*) *crateriformis* Alcock.

Journ. Asiatic Soc. Bengal, LXII, 2, viii, 1, 2 (1893).

St. 209, 366 m., gr. br. m. r., 1 living (32 mm. greatest height, calicular opening 28 × 23 mm.), 6 dead (largest straight, 38 mm. high with calicular opening 38 × 35 mm.). (Alcock's specimen was from Bay of Bengal, 573 fms.)

This is a good description, but of course the pedicular scar is not a specific character, while the shape varies greatly. The calicular orifice varies from almost circular to flattened, with breadth to length as 3 to 5. The shape may be upright and is usually cornute, often bent. The rootlets are only found on the lower half and may be merely blunt projections on the corallum, but clearly in the young have a real function for support. One dead specimen is a conical corallum on the septa of which a second polyp has settled; here there are confluent rootlets forming a large base extending over many septa. These

* We have found it most inconvenient in our systematic studies to place our references in a "List of Literature", an appendix. For corals we require (1) name of publication, (2) volume of same (roman), (3) the page (arabic), (4) if figured the plate (roman) and the figures (arabic), (5) the date of publication, and these are given in each reference. Often there is no volume number, merely date, which then is given in the place of (2) above.

It may be added that throughout this Report descriptions have been greatly reduced where photographic figures are given, these being regarded as of peculiar importance for purposes of identification.

rootlets of *Flabellum* must grow by the polyp edges overflowing or growing out over the rim of its corallum, which is subsequently built up higher, for there are no signs in any specimens of this or other species that we have examined of the epitheca being perforated. The position for a rootlet here is normally over one of the larger 24 septa, which is continued down the rootlet for some distance.

Genus *Conotrochus* Seguenza.

Conotrochus Seguenza, Mem. R. Ac. Sci., Torino, ser. ii, 477 (1864).
Pleurocyathus Moseley, "Challenger" Reports, 159, ii, 1 (1881).
Ceratotrochus (*Conotrochus* et *Phlœocyathus*) Alcock, "Siboga" Exp. 12, ii, 8 (1902).

This genus clearly belongs to the Flabellidæ and is separated from *Ceratotrochus* by its single wall being epithecal and its columella being fasciculate, its rods perhaps twisted; these points are made clear by Seguenza. That the epitheca is depressed as it passes over the outer edges of the septa allows an illegitimate reference to costæ, which do not exist. It would seem probable that Seguenza's work was unknown to Moseley.

Conotrochus brunneus (Moseley). (Pl. V, figs. 11 and 12.)

Pleurocyathus brunneus Moseley, "Challenger" Reports, 159, ii, 1 (1881).
Ceratotrochus (*Conotrochus*) *funicolumna* Alcock, "Siboga" Exp. ii, 1, 6 (1902).
Ceratotrochus (*Phlœocyathus*) *hospes* Alcock, "Siboga" Exp. 12, ii, 8 (1902).

St. 145, 510 m., gn. m. s., 10 living and 2 dead.

The following description is founded on 10 specimens all living when obtained, the previously known forms consisting of 1 living and 3 dead coralla. An examination of these with Seguenza's *C. typus* may show that the living and fossil forms are inseparable.

Corallum attached, generally becoming free, conical; calicular opening rounded or very slightly oval. Whole covered by epitheca, raised over edges of the septa into ridges (not costæ), usually with numerous circular "growth" markings, whole wall relatively thick, the epitheca strengthened by internal deposition of corallum.

Septa: upper edges slightly below an upstanding rim of epitheca, broad at their upper edges, sloping nearly perpendicularly to the marked central columellar area, edges usually smooth, but growth of septa is by longitudinal ridges and each of these may end in a small tooth; surfaces granulated; four cycles, I to III larger, joined to the columellar mass, and alternating with them those of IV smaller, not so connected and extending much less deep into the corallum.

Columella always distinct, twisted rods usually strengthened in places by horizontal trabecular junctions, the whole forming a rounded or slightly oval upstanding mass.

Highest 18 mm., average 14 mm., diameter calicle 9–13 mm.

The young polyp attaches itself to any solid object, in three specimens a bivalve shell, a piece of gorgonian and an irregular fragment of some mollusc. When possible its base broadens out to 2 or 3 mm. before the cone grows up. Then it usually becomes free, breaking off the decaying object to which it is attached. It often bends at an angle, so that its attachment seems to have been sideways, the corallum remaining straight. When it becomes free there is a tendency for the base to become somewhat pointed. The external "growth" markings we suppose to represent periods of food stimulation.

The upper edges of the septa are usually about ·5 mm. below the edge of the epitheca and, while in deep specimens they remain thus, in shallow forms may be visible above the epitheca as in Alcock's *funicolumna*. There is considerable variation in the granulation of the septal sides and edges, but the granules are always small, perhaps in the largest specimens smallest. The depth and size of the columella is a growth variation, the range being from 1 to 5 mm. in depth and from one-sixth to nearly one-third the diameter of the calicle; its surface is always clearly upstanding above the septal junctions to itself. In one specimen the columella looks to be formed of two irregular rods, but these consist respectively of 5 and 4 rods fused by subsequent deposition of corallum. In another it has about 20 rods all separate on the surface. In all cases the rods are twisted and irregularly interlocking, so that a very distinct columella-mass results.

The three "species" are clearly one, since they fall within the range of our suite. *C. hospes* is founded on a specimen apparently grown slowly in unfavourable conditions, the corallum thickened within its calicle by deposition as may be seen in most reef colonies of astræids, especially where they grow out and shade their sides.

V. TURBINOLIDÆ.

Genus *Desmophyllum* (Ehr.).

Two small young living specimens, St. 111, ? r., g 73–165 m., and 153, 256–293 m., both indeterminate.

A third, in spirit St. 185, 2000 m., gn. m., may be placed here, but it is a very young form with its septa joined in the centre.

Genus *Caryophyllia* Lam.

Caryophyllia clavus Scacchi. (Pl. I, fig. 1.)

Cyathina pseudoturbinolia Ed. & H., Ann. Sc. Nat. 3e ser., IX, 289, ix, 1 (1848).
Caryophyllia clavus Ed. & H., Hist. Cor. 15 (1857); Duncan, Trans. Zool. Soc. VIII, 311, xlviii (1873); Lacaze-Duthiers, Arch. Zool. Exp. Gen. 3e ser., V, 37, i, ii (1897); Marenzeller, pars, "Valdivia" Exp. XVII, 281, xvi, 9 (1904).
C. communis Moseley, pars, "Challenger" Reports, 135, i, 4, 5 (1881).

St. 119, 1207–1463 m., 27 specimens dried off. The average size of calicle is 27 × 22 mm., and the average number of pali 16. The maximum sizes are 32 × 29 mm. and 32 × 30 mm., 17 and 16 pali; two (23 × 20 mm.) have 14 pali each and two (29 × 24 mm. and 27 × 22 mm.) have 18 pali each.

St. 122, 732 m., gy. gr. m., 2 living and 4 dead; largest 25 × 20 mm. and 20 × 16 mm., 14 and 15 pali; low growing forms.

St. 143, 797 m., gr. s., 1 living, 20 × 15 mm., 14 pali.

St. 144, 31 m., c. sh. s., 1 living, 25 × 16 mm., 14 pali, very exsert septa and rather massive growth; anchorage outside Fadifolu Atoll, Maldives.

St. 185, 2000 m., gn. m., 86 living, 52 specimens have the calicle varying in length from 20 to 29 mm. and breadth 18 to 27 mm., the average difference about 4 mm., but in one case 9 mm. longer. Of these 33 have 16 pali, the number varying between 14 and 19. A partially regenerated form (20 × 20 mm.) has 20. 22 coralla of calicular length 10 to 19 mm. vary from 10 to 14 pali, and one form, 6 × 5 mm., has 27 septa and 6 pali.

This species has been sufficiently described, with the photograph now added (Pl. I, fig. 1), and the variation in its main characters is shown above. All forms are cornute, and with growth and increase of weight appear to become free, tumbling to one side. The polyp seldom extends more than 5 mm. down outside the corallum, which shows low costal ridges covered by an epitheca, which has a tendency to be completely dissolved away. There is relatively little variation in thickness of septa and pali, but the former vary in exsertness. The columella is usually markedly below the palial level and consists of a small number of relatively broad, twisted ribands: it may fill up the central space as an elongated area or be almost round, when the calicle is rounded. Several of the specimens have parts of their coralla broken and regenerated (central corallum on Pl. I, fig. 1).

Caryophyllia grandis n. sp. (Pl. I, fig. 2.)

St. 145E, 494 m., 71 specimens.

Corallum dark coloured, mauve purple; cornute and markedly compressed; attached by a fine peduncle when young, generally free later and bent as in *clavus*: polyp extending down outside for 5 mm.; lower part covered by epitheca, which is often dissolved away. Costal ridges variable, but always low.

Twenty-four septa (I, II and III) broader, thicker and markedly more exsert, rather spiny on sides and often showing growth-lines, not visibly connected to columella, but joined by trabeculæ below. Then 24 septa (IV) much narrower and lower, with 24 pali plate-like, varying up to 4 mm. long, and spiny sided. Lastly 2 smaller and thinner septa (V) on either side of IV and quite distinct.

Columella twisted and relatively coarse ribands, generally forming a rather solid mass well below palial level; in a narrow calicle about one-third its length by 2–3 mm. broad, but with increase in breadth becoming more oval.

Measurements: Of 57 apparently adult forms (calicle at least 20 mm. long) 9 are 30 to 34 mm. long. The length of calicle to breadth is as 1·1 to 1·5 : 1, the average being 26·2 by 20·8 mm. The larger forms usually have 24 pali, the average being 21·8.

The species is characterized by its shape and its large number of pali. One corallum (9 × 8 mm. calicular length) has 12 pali and there are 14 intermediate-sized forms (10 to 19 mm.) with pali varying from this to 20.

The species differs from *C. clavus* in a certain appearance of density, due to the maximum number of septa in this species being 8 + 8 + 16 + 32 = 64 as compared with 6 + 6 + 12 + 24 + 48 = 96 here, but undue emphasis should not be laid on the cyclical arrangement. The septa also are thinner, finer, less spiny and less markedly exsert. Odd specimens of *clavus* and *communis* referred to by Moseley, Duncan and Marenzeller may well belong to this species.

Caryophyllia scobinosa (Alcock). (Pl. III, fig. 7.)

"Siboga" Expedition, 8, I, 2 (1902).

St. 108, 786 m., gy. m., 172 living and a large number of dead specimens.

St. 125, 805 m., lt. br. m. over gl. cl., 1 living.

Corallum cornute, rather flattened, varying in height but never tall, all bent and free; most with tiny scar of former attachment.

Externally two zones, that near the calicle seldom more than a quarter the height, covered by polyp tissue and translucent, and the remaining three-quarters opaque with surface worn. Costæ in consequence made more conspicuous below but subequal, those of cycles I and II slightly more prominent.

Septa I and II very markedly exsert, septa IV against same much more exsert than III. All septa relatively thin and granular; no conspicuous growth-lines on sides. Septa I and II sloping perpendicularly, but deep down connected to the columella. Septa III with very conspicuous broad flattened pali, remarkably upstanding, their central line opposite the inner edges of septa I and II. Septa IV same breadth as septa III outside the palial region.

Columella as a rule deeply placed below the upstanding pali, rather flattened and narrow, generally consisting of 3–4 flattened riband-like, twisted processes.

Size of calicular opening 15 × 11, 12 × 10, 11 × 10, 12 × 11, 13 × 12, 10 × 9 mm., etc.

These specimens are inseparable from Alcock's species (6 specimens from 535 and 794 m.), the large majority the size of his smaller forms. There are three large specimens, calicular openings 19 × 15, 21 × 14 and 19 × 14 mm., the highest not more than 15 mm., and hence with remarkably open calicles. All these three have 14 pali, while in the bulk of specimens 12 is the regular number.

Caryophyllia mabahithi n. sp. (Pl. III, fig. 6; Text-fig. 1.)

St. 34, 1022 m., gn. m., 29 living, 31 recently dead.

St. 143, 797 m., gr. s., 1 recently dead, 10 mm. high and calicle 10 × 9 mm., with two additional septa.

St. 176, 655–732 m., gn. m. s., 3 recently dead.

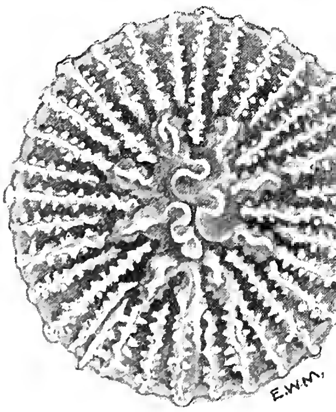

Fig. 1.—*Caryophyllia mabahithi* n. sp. × 5.

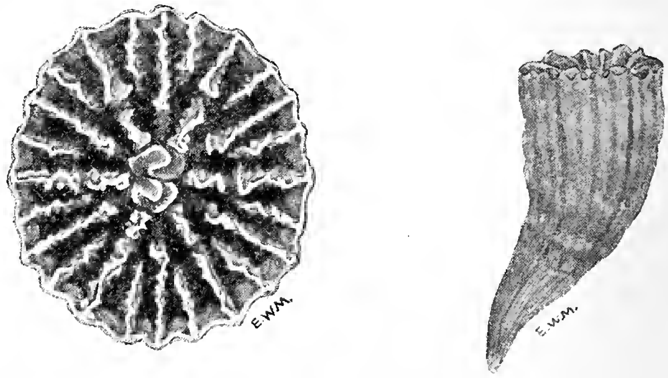

Fig. 2.—*Caryophyllia cornuformis* (Pourtalès). Side view × 3·5, and mouth × 9·5.

Corallum horn-shaped and bent to one side, unusually low and broad, slightly compressed; free, with flat scar of former attachment. Often with transverse growth markings externally. Costæ of all septa low ridges.

Septal cycles in eights; septa I rising markedly higher than the thecal wall; septa II much lower, with flattened pali in front of same; septa III narrower and less massive than last, complete in number. All septa with longitudinal growth-lines and these studded with low spines or granules, giving a rough appearance.

Columella relatively shallow, consisting of 1 to 4 rather coarse twisted ribands.

Measurements : about 13 mm. high (measured vertically, not round the bent horn) ; calicular opening 12 × 10, 12 and 10 × 8, 11 and 10 × 9, 9 and 10 × 9, 10 and 11 × 10, 9 and 8 × 7 mm., etc.

The number of pali, viz. 8, which is a very constant character, allies the species to *C. octopali* Vaughan,* of which there were three specimens from Hawaii, 281–371 fms. It differs in its more definite cornute shape and its very narrow base ; its septa III are always much narrower than II. Septa I are often markedly exsert, but there is great variation in the range here, while II and III are much lower and nearly similar. The twisting of the columella-ribands on one another is most noticeable, and in rounded calicles gives a rather solid appearance.

Caryophyllia cornuformis (Pourtalès). (Text-fig. 2.)

Cat. Mus. Comp. Zool. I, 9, i, 14–15 (1871) ; amended Bull. Mus. Comp. Zool. V, 188 (1878).
C. vermiformis et *pourtalesi* Duncan, Trans. Zool. Soc. VIII, 316, xl, 13-16, xlii, 3–10 (1871).
C. carpenteri et *simplex*, Duncan, Trans. Zool. Soc. X, 237, xliii, 28–34 (1878).

St. 103, 101 m., c. s. sh., 2.
St. 105B, 238 m., gn. m., 32 specimens mostly living, their pointed ends bedded in small, hemispherical Polyzoa.
St. 112, 113 m., cr. r., 1 living.
St. 178, 91 m., c. gn. s., 2 living, 2 dead.

The above four species have three cycles of septa, but Pourtalès' original description is scanty and his figure bad ; I have, however, two of his specimens before me, both relatively large and old forms. Duncan has confused Pourtalès' description of *pourtalesi*. For the rest he founded three species on three specimens from 539 and 740 fms. in the Atlantic. They are all figured, presumably correctly ; not one can be regarded as a healthily grown specimen, and the last two are obviously worn down externally. Here is the description of our suite of nineteen specimens :

Corallum cone-shape, free or with tiny base of attachment, generally with transverse, ridged growth-markings.

External surface with finely granular costæ, those belonging to septa I and II sometimes a little more prominent, all rather broad and rounded.

Calicular opening almost round. Septa very slightly exsert ; I broader and falling perpendicularly to centre ; II less broad, with 6 flattened pali in front of same ; III thinner and extending about a third of the way to the centre ; all with longitudinal growth-lines, looking as if covered with low spines when the calicle is looked into.

Columella 1 to 3 twisted riband-like processes, the depth of its surface depending on the growth of the whole corallum.

Height varies up to 15 mm., diameter of calicle to 7 mm.

* ' U.S. Nat. Mus.,' Bull. 59, 74, v, 2 (1907).

Caryophyllia compressa n. sp. (Pl. II, fig. 4.)

St. 105B, 238–293 m., gn. m., 41 specimens, about half dead.

Corallum with a fine-pointed attachment or more usually free, gradually expanding to the calicular opening, which is about twice as long as broad. Sometimes transverse growth-lines externally.

Costæ well marked, those of cycles I and II more outstanding, the two primary at the ends of the calicle higher and often forming distinct wings, all of about equal thickness and finely granulated.

Septa I and II about 3 mm. exsert, while septa IV against the same about 2 mm. and III 3 mm. lower, all measurements above thecal edge. Septal sides with longitudinal growth-lines often shown in granules; septal edges untoothed. Septa I and II markedly broader, dropping perpendicularly to level of columella about 6 mm. below, then joined to same by trabeculæ. Septa III and IV equal, but III joined up to flattened pali, which are often spiny, and so to the columella.

Columella a line of twisted ribands deep down the centre of the calicle about 5 mm. below the top ends of the highest septa, always conspicuous.

Height varying to 25 mm.; calicular openings such as 20 × 11, 17 × 9, 17 × 8, 25 × 12 mm.

About 10 specimens are in good condition. The wings formed by the terminal costæ variable, but usually well marked and up to 3 mm. broad. While some specimens would seem to have been almost entirely covered by polyp tissues, in others the extrathecal portions of the polyps have been killed, so that the polyps form mere caps. In two specimens this has gone so far that new polyps have grown out in the old cups. Where the calicular opening elongates, an extra pair of septa of cycle III may appear, with corresponding additional pairs of septa of cycle IV, but 12 thin conspicuous pali is a regular feature.

With these specimens were 7 young forms, mostly much broken. One specimen 6 mm. high 8 × 4 mm., calicle has 12 septa of I and II and the commencement of cycle III without pali as yet and none of IV.

As to previously described species *C. clavus* var. *transversalis* Moseley (" Challenger " Report, 134) is not nearly so flattened and has no trace of wing costæ. It is difficult to compare with *Acanthocyathus grayi* Ed. & H.,* a single specimen of which of unknown origin is represented with 16 pali—a character shared by its fossil companion *A. hastingsii*.

Caryophyllia sewelli n. sp. (Pl. II, fig. 3.)

St. 209, 366 m., gn. br. m. r., 3 living and 30 dead coralla.

Corallum elongated, cornute, expanding gradually to the calicular end; evenly costulate externally, finely granular, broad lines.

Septa I and II markedly more exsert than rest, thecal wall rising higher on sides of same and including the neighbouring septa (IV). Septal sides varying from almost smooth to longitudinal ridges, perhaps with lines of spines parallel to the septal edges. Septa III and IV much narrower.

Pali crown very marked, 12 broad flattened rods with spiny sides, sometimes an extra pair in compressed coralla.

* 'Ann. Sci. nat.' 3e ser., IX, 293, ix, 2 (1848).

Columella generally 2 to 4 rods arranged in a line, their ends markedly lower than the tops of the pali, sometimes in a group less regularly arranged.

Measurements : height up to 40 mm. ; calicle up to 20 mm. across by 15–18 mm.

Evidently there had been a great mass of these corals growing together attached to sides of each other, as described by Alcock in *C. paradoxus** and Moseley in *C. profunda*,† from which they are separated in the great regularity of their septa and pali, which only in 5 specimens show an extra pair. A number of dead pieces were cut or broken, but in no case was any communication found between the cavities of the calicles ; this does not preclude the possibility of the arrangement being due to extrathecal budding, but this seems unlikely. In 1 living and 5 dead specimens the polyp has been partially killed externally and new calicles have grown out in the centres of their predecessors. In the living corals the outer parts of the septa are purple coloured.

The dead coralla show the costæ levelled down and smoothed. The exsert portions of septa I and II are commonly removed. The septa are all thickened, a characteristic more marked in the pali which appear more massive than in the living corallum of any described species. This, too, is seen in the columella rods, which this external deposition of lime has often fused together.

Caryophyllia paradoxus Alcock.

"Investigator" Report, 14, i, 2 (1898).

St. 209, 366 m., gr. br. m. r., 1 living, broken off its base of attachment.

A simple corallum with pali rather like "little ragged lobules of the septa" and columella "a good-sized mass, consisting of loosely-connected, irregularly-twisted, often ragged and granular, processes". Evidently a most variable species.

Genus *Paracyathus* Ed. & H.

Ann. Sci. nat. 3e ser., IX, 318 (1848) ; Cor. II, 52 (1860).
Polycyathus et *Agelecyathus* Duncan, Proc. Zool. Soc. 1876, 433.

The genus presents little difficulty of determination. As to species we found about 30 described species, based apparently on less than 40 specimens in all, besides a few founded on proper suites. Size, regularity in height of septa, nature of pali and of columella are their chief characters, the greatest stress laid on the last two ; some coralla were obviously distorted and others immature. Selecting specimens out of the collection before us and destroying the rest, we could easily add a dozen equally good "species". We thus must decline to recognize few, if any, of such "known" species, as there is no uniformity in any of the above characters in any of the present series, except in size.

In contrast we have a careful study by Lacaze Duthiers‡ of specimens from the Gulf of Lions, which he assigns to *P. striatus* and *P. pulchellus*, both being species placed by Edwards and Haime§ in their division "a palis entiers". They differ from our species below in not having the septa of I and II so markedly large, but more especially in having a columella of 15 to 25 rods.

* '"Investigator" Report,' 14 (1898).
† '"Challenger" Report,' 138 (1881).
‡ 'Arch. Zool. Exp. Gen.' 3e ser., V, 120–31, vi, vii (1897).
§ 'Cor.' II, 55 (1860).

There are also many coralla from the West Indies supposed to belong to *P. de filippii* D. & M.,* but neither the description nor the figures of these authors show the specific characters of our species below (*gardineri*). Vaughan† identifies *P. confertus* Pourtalès,‡ the original accounts of which are scanty, with *de filippii*. Neither Vaughan's nor Pourtalès' figures add much to earlier accounts, nor do they indicate agreement; hence a redescription of the numerous American specimens is required.

From the Indo-Pacific, eliminating all founded on single specimens, *P. parvulus* Gardiner|| (11 specimens), *P. lifuensis* Gardiner§ (2) and *P. fulvus*|| (3) are separated *inter alia* by the nature of the columella. *P. gardineri* Vaughan¶ is described in terms applicable to one of our species, his fig. 4*a* identical with several specimens. As we have a long series, we append a fresh description, founded on our suite of coralla, and hence indicative of the variation of the species.

In the species *P. conceptus* below, a regular method of reproduction is by outgrowths of polyps from the extrathecal part of the polyp. The latter is a cap of two layers of tissues, with the cœlenteric cavity between, seated on the top of a coral cup to which its lower part fits closely over all its structures, which, indeed, it is building up. The lower surface here is covered by somewhat flattened calicoblastic ectoderm and the free surface above by a columnar epithelium. It is apparently where these two qualities of ectoderm meet, just above the epithecal formation on the stem, that "budding usually" takes place. The new corallite is deposited upon its parent's column, but later on its polyp, as the parent corallum grows higher, severs its connection with its parent.

It frequently happens with coral polyps that one may be killed over some part of its surface, when the still living part will grow out and regenerate the whole. This frequently takes place at the position described above, where the naked epithecal surface below becomes overgrown by worm, barnacle or other organisms which fight to grow along the coral stem at the expense of the polyp; in nearly all cases cause and effect are apparent, and we conceive this to be the cause of the formation of the buds in *P. conceptus*. They do not produce a "colony" comparable to that of the "colonial" corals in that all the daughter-polyps quickly become independent of parents and of one another. This may be a sufficient difference to be deemed a generic character, but we require to ask ourselves whether the Linnean terminology is intended merely for cataloguing, or to indicate real relationships. In the case before us the corallites present all the characters typical of *Paracyathus*, and because they are prolific parents, in an asexual manner, we see no reason to adopt for them a surname which hides their descent.

The above remarks apply to the whole genus *Polycyathus*, but the descriptions of its recorded species are founded on an insufficiency of specimens to determine the species of sedentary animals, while they were based on incorrect ideas of structure and formation

* Duchaissaing et Michellotti, 'Mem. Cor. Antilles, Turin,' 60 (1860). A clump of specimens ("off Barbadoes") before us are of small size, largest calicle 7 by 6 mm., and were almost entirely covered by polyp tissues. A specimen, collected and termed *confertus* (Florida, 97 fms.) by Pourtalès is almost certainly within the range of *de filippii*.

† 'Bull. U.S. Fish. Comm.' 2, 292, I, 1, 1*a* (1901).

‡ 'Cat. Mus. Comp. Zool.' 11, vi, 11–13 (1871).

§ 'Willey's Zoological Results,' 165, xix, 4 (1899).

|| 'Journ. Asiatic Soc. Bengal,' LXII, 139, v, 2 (1893).

¶ 'U.S. Nat. Mus.,' Bull. 59, 68, iv, 4*a*, *b*, 3 specimens (1907).

of corallum. Thus Duncan* gives us the above genus and also *Agelecyathus*, which is assuredly the same genus. Three species of these genera were described by him on three specimens, all seemingly young forms. The largest is *atlanticus*, calicle 7 mm. broad, and there is so remarkable a dissimilarity between the descriptions of its pali and columella and the figure of its enlarged calicle that we dare hazard no guess as to its relationships. Pending re-examination of these types of genera and species, we consider that they must disappear from our literature.†

Paracyathus gardineri Vaughan. (Pl. III, fig. 5.)

U.S. Nat. Mus., Bull. 59, 68, iv, 4*a*, *b* (1907).

St. 43, 83–100 m., 1 living, small, overgrown by organisms; doubtful.
St. 106, 183–194 m., gn. m., 1 dead.
St. 149, 238 m., cr. r. lth., 5 dead.
St. 157, 229 m., cr. r., 170 dried off and many in spirit, over 90% living when obtained.

Corallum fixed by a broadened base of attachment, above this a narrower stem rising with constantly increasing diameter. All specimens detached, a few secondarily pointed at the base, some broken, showing a heavy, secondarily thickened wall; all much overgrown by organisms, most to within 2 or 3 mm. of the edge of the calicle.

Costæ largely obliterated by epithecal deposition below, closely and evenly packed, relatively thick and equal in size; in thicker, more exsert portions granules almost regular in lines across the edges of the costæ.

Calicle: opening varying from round to oval, but length by breadth seldom beyond 4 by 3, most elongated, general appearance dense. Terminal septa cycle I, 2 septa of same on either side, all markedly more exsert, massive and broader, and the narrower and less exsert septa of cycle II intermediate; septal cycles III and IV complete, thinner, narrower and less exsert. All septa untoothed with longitudinal growth-ridges on sides, these with low spines, their appearance granular when looking into the calicle, all closely set and gradually thickening where the theca joins them.

Central area of calicle variable, generally 2 to 3 mm. below the exsert ends of the broader septa, the whole more or less flattened, palial and columellar area here about one-third the diameter of the calicle.

Pali or paliform lobes: before all septa of cycles I to III, thick, rounded, flattened, or angular rods before I to narrow upstanding plates; compressed plates progressively thinner before II and III, but all varying greatly in thickness. Pali generally single, but many bilobed, if the filling of space so demands, this doubling sometimes markedly visible off the inner edges of terminal septa of I; where the sides of the calicle slope towards the centre, often chevron-appearance, but no fusions visible from above.

Columella: general character usually 3 or 4 rods, relatively large, in a line between the primary septa at the ends of the compressed calicle; the 12 central pali and this regular line of columellar rods usually filling in the central space, additional rods only appearing occasionally where gaps occur.

* 'Proc. Zool. Soc.' 1876, 433, xxxviii, 14–16, xxxix, 1–6.

† While here there is no question of any connection between the cavities within the thecal parts of two attached coralla, there is said to be such communication in *Cœnocyathus* Ed. & H. and *Gemmulatrochus* Duncan. *Vide* Duncan, 'Journ. Linn. Soc.' XVIII, 33 (1884); also Doderlein, 'Mitt. Zool. Sta. Neapel,' XXI, 118 *et seq.* (1913).

Size varying up to 3 cm. high ; length of calicle up to 17 mm. and breadth equal to two-thirds of length, the averages about 14 mm. by 10 mm.

The chief characters of this species as apart from size and compression lie in the markedly exsert, conspicuous and broader septa I and II, in the regularity of the pali seldom bilobed, and in the columella primarily consisting of a line of conspicuous rods down the central valley. But with each character, especially the last, there is variation induced by growth-shape, this presumably correlated with an environment of Foraminifera, worms, barnacles, Polyzoa and other sedentary organisms overgrowing the columns of the corallites. Prominent growth-lines show alternately on either side of the septa. In sections centres of calcification or deposition of corallum are visible, and this deposition is more extensive alternately on opposite sides of the septa, the edges of which, when viewed from above, may have a zigzag appearance. So far as we can judge, the dark " centres of calcification " consist of grains of limestone arranged irregularly in respect to one another, whereas crystals of aragonite in further thickening fit on to one another, facet to facet.*

All the specimens appear to be adult. None show any budding, nor are there any young attached coralla on their sides, such as might have been expected.

Paracyathus conceptus n. sp. (Pl. IV, figs. 8 and 9.)

St. 157, 229 m., cr. r., over 200 specimens.
St. 208, 732–805 m., gr. br. m. r., 12 living and 2 dead.

Coral with broad base of attachment, upon this a cone-shaped corallum growing up, often bent ; secondary coralla budded off the sides of same, where the polyp tissues cover the coral outside, the result a low bush with 2 to 6 or more upstanding calicles. Basal part of the whole covered by a thick deposition of epithecal corallum, to which sedentary organisms freely attached themselves, the separate corallite-polyps becoming physiologically separated. Stems of corallites usually or nearly solid below, epitheca and theca broadened and interior largely filled up ; no communications between central cavities of corallites.

Calicle overlapped outside by the edge-zone of the polyp, usually for about 5 mm. In this part costæ (the peripheral parts of all visible septa) rather thick, subequal in size, granular edges. Calicular opening round to oval, sometimes highly compressed, with sides much higher than ends, the theca at the ends of the valley much lower than at the sides.

Septa all exsert, I and II broader, thicker and slightly more exsert, up to 2 mm. Edge of theca formed by the junction of all the septa, quite regular in height between the septal tops. All septa with longitudinal growth-lines, which show even in their costal parts, edges entire, whole looking granular from surface view of calicle. Septa I to IV

* *Vide* Dr. Ogilvie, ' Trans. Roy. Soc.' 187, 83–345 (1896). This character of " centres of calcification" initiating the growth of septa is common to all the Turbinolidæ. In sections they are situated at some distance from one another. Corallum is deposited all round them. In the line of the septum it meets, but on its faces it may show raised ridges extending down the septa, commonly termed lines of growth. These often are set with low, pointed spines which may give a rough appearance when looking into the calicle.

fairly distinct and graded in size, very close set, regular and relatively thick, the last cycle in any system absent if space does not allow, while, if growth gives room, some septa of V present.

Pali : rods before septa I, a little flattened before II ; flat plates before III, generally divided into 2 or 3 lobes.

Columella : central space open, closed in by a number of small upstanding rods, their surface below that of the pali; number variable, but in average coralla 20 or more, all joined below by trabecular junctions extending from the larger septa ; between the septa open interseptal spaces.

Measurements : maximal size of bush about 5 cm. high by same in diameter, usually much lower ; of calicles, if round, about 15 by 13 mm. grading to compressed forms 21 mm. long by 8 mm. and upwards in breadth ; top of columella situated up to 5 mm. below exsert ends of septa.

These corals from St. 157 were obtained by a 4-ft. triangular dredge and appear to have been torn off a firm, level substratum by its sword. About half are intact, suggesting that the substratum was not as hard as the corallum, which at the base of the corals is almost solid ; some specimens suggest that the material, of which the bottom is composed, is coarse sand formed of organic remains which have become solidified. All were covered with epizoites, amongst which were observed barnacles, bivalves, brachiopods, foraminifera, sponges, *Spirorbis* and polyzoons, there was much growth of branching gorgonians.

The young coral usually gives off its first daughter-corallite while its stem is less than 10 mm. high, all this basal part subsequently filled up externally by a thick deposition of epithecal corallum. Generally there are no more than 3 to 6 of these basal coralla, which may become almost equal in size, any further formations of daughter-coralla at a higher level being frequently seen to be correlated with unfavourable conditions, and perhaps death of single coralla. In one dead specimen there is apparently an almost perfect example of " fission ", but another specimen, in which the polyp has been killed at one end and in which the septa have grown up to form a fresh theca, shows this to be a quite false idea ; another small corallum suggests that fusion is not impossible.

The growth changes in the coralla are very regular. The youngest bud about 1 mm. in diameter has 12 septa in two cycles, with the centre of the calicle open. At 2 mm. most septa of cycle III are visible, and septa of I join together in a mass of twisted trabeculæ in the central space. At 3 mm. there are upstanding rods upon this and some pali have appeared, while at 4 mm. the genus is quite clearly *Paracyathus* ; at 5 mm. the regular arrangement of pali and columella is clear. So far growth has been rapid, the corallite 10 mm. or more high, its stem clean, with no foreign growths on same. From this stage there is next an opening out of the calicular mouth, which attains an average diameter of 11 to 14 mm., but the proportionate sizes change but little, the stems thickening by epithecal deposition. The collection suggests that now there is a great slowing down in the growth-rate of the calicles, and many corallites are found to be dead ; at the same time there appears to be a heavy deposition of corallum internally, giving almost complete solidity to the corallites in their lower parts.

Lastly, we would remark that although there are large numbers of *P. gardineri* and this species from St. 157, there is not a single example which suggests any method of budding in the former, nor is there even one which cannot be easily separated specifically by the characters of its columella.

Paracyathus stokesi Ed. & H.

Ed. & H., Ann. Sci. nat. 3e ser., IX, 319, x, 7 (1848); Cor., 52 (1860).
Paracyathus agassizii Duncan, Trans. Zool. Soc. VIII, 319, xliii, 5–8 (1873).

St. 45, 38 m., lith., 2 living, attached to calcareous sponges.
St. 177, 274–366 m., gn. m. r., 1 living.

There are two excellent descriptions with figures of this species, showing the very characteristic central area of the calicle, depressed in the centre and crowded with columellar rods merging into a paliform area, the latter with pali on the lines of the septa. There is nothing like this in *P. striatus* and *pulchellus* as described by Lacaze Duthiers.*

The largest specimen (St. 45) has been broken off its base, where it is about 10 by 12 mm. in diameter, the coral wall here very thick and overgrown by calcareous algæ. The calicular opening is 21 by 11 mm., the central part 6 mm. deep. There are 100 septa; these are little exsert, tightly packed with very spiny sides. They fall almost perpendicularly inwards for half the radius; their outer parts are untoothed, but all septa except the last cycle have paliform teeth, generally before I and II much flattened, perhaps divided into 2 or 3, the others with a series of teeth (up to 8) merging centrally into about 100 fine rods which form the columella. All this central part is stained black-purple, which shows also in the broken base.

The other specimen from St. 45 has calicle 15 by 9 mm. and is 12 mm. high; it is attached by a broad base, and the last cycle of septa is less developed; the whole cup, theca and costæ included, is similarly coloured. Its base is white and is attached to a polyzoon branch, covering upwards of 90 sq. mm. From this a cone arises, 15 mm. high, with a round calicle 9 mm. across, this part dark purple. From within this calicle a new cup was growing up, now 6 mm. in diameter, as seen by a new thecal formation; its septa clearly continuous with those of its parent.

In addition to the above species two specimens from St. 89, 193 m., s. sh. r., and St. 112, 113 m., cr. r., suggest *P. porphyreus* Alcock.† Four further coralla from St. 72, 73 m., c. s. sh., may be related to *P.* (*Polycyathus*) *andamanensis* Alcock,† but it is not always easy to determine odd specimens. One calicle appears to have been dividing into two; there is no trace of any colouration.

Genus *Heterocyathus* Ed. & H.

Heterocyathus æquicostatus (Ed. & H.).

Gardiner, Marine Inv. S. Africa, III, 104–14, 125, iii, 1904.
Harrison and Poole, Proc. Zool. Soc., 1909, 913.
Harrison, Proc. Zool. Soc., 1911, 1021–26.
Bourne, Trans. R. Soc., Suppl. Vol., 1905, 193, 213–26.

St. 53, 13·5 m., r. sg. sh. lith., 5 living and 1 dead.
St. 80, 16–22 m., c. s. sh., 22 coralla about half living.
St. 149, 238 m., cr. r. lith., 3 dead.

* 'Arch. Zool. Exp. Gen.' 3e ser., V, 122 (1897).
† 'Journ. As. Soc. Bengal,' LXII, 140 et 143 (1893).

We have before us only about 16 living and the same number of dead specimens. Of these two of the living forms (St. 53) have larger and denser coralla than any we had previously seen ; this is a character usually associated with shallow water. Every other costa is peculiarly thick, broad and alternates with a thinner costa near the base of which is an opening to the chamber of the sipunculid (*Aspidosiphon*), the larger chamber having its main opening on the flat base of the corallum. A sixth specimen was decalcified ; and the gross features of its polyp were found to agree with Bourne's and one author's descriptions.

Heterocyathus heterocostatus Harrison.

Harrison, Proc. Zool. Soc. 1911, 1026.

St. 45, 38 m., lith., 2 living discoid growths detached from shells.

St. 72, 73 m., c. s. sh., 24, of which most are attached near the mouths of relatively large conical shells, about half living, in two cases 2 coralla to a single shell, one near the mouth and the other near the point.

St. 73, 91 m., gn. m. s. sh., 3 dead.

St. 207, 375 m., gr. br. m. pt., 9 living when obtained, all small, averaging 3·5 mm. across mouth, 4 seated on conical shells.

We must leave some future worker, with a long series, to determine whether this is a good species, a synonym of *alternatus* Verrill or a form of *æquicostatus*. Most of the larger forms have settled on elongated conical mollusc shells, and the polyps are attempting to grow over them and cover them with corallum. The young polyp settles on a shell. It then spreads, to form beneath itself a discoid corallum covered by epitheca below. When it has attained a breadth of 3–4 mm., it commences to grow upwards, its base still continuing to spread over the shell. The association with a sipunculid is subsequent, if it takes place at all.

In addition to the above there are three coralla from St. 72 attached to a conical mollusc of 7 cm. long. They are 7, 3 and 5 mm. in diameter and the two larger have broad bases. Their genus may be uncertain, but the characters of their calicles place them with *Heterocyathus*, nearest to this species.

Genus *Trochocyathus* Ed. & H.

Trochocyathus (?) *pileus* Alcock.

Alcock, "Siboga" Exp. 15, ii, 11 (1902).

Two specimens from St. 106, 183–194 m., gn. m., are referred here ; they are of a dark slate colour, 17 and 13 mm. high, calicular openings 12 × 7 and 10 × 7 mm. Each has a scar of detachment at the base 2 or 3 mm. across, in which septa I are visible, and each has a very slight wing expansion here. The much higher coralla, as compared with Alcock's four specimens and especially with his figure, give a different appearance, and the theca is a very distinct structure ; the columella is described in Alcock's words as "an elongated patch of pinnacles not distinctly delimited from the pali".

The outsides of our coralla were not covered by polyp tissues when dredged, whereas Alcock's references to *Tropidocyathus lessoni* suggest to us that his were ; hence the costæ in our specimens are less even and regular. We dislike to found a new species on two specimens only and so refer to the nearest description of a known species.

Trochocyathus oahensis Vaughan.

U.S. Nat. Mus., Bull. 59, 73, vi, 5, 6 (1907).

A specimen from St. 207, 375 m., gr. br. m. pt., identical with the above species, diameter 4–4·5 mm. Vaughan remarks that this form bears the same relationship to discoid *Trochocyathus* as *Diaseris* bears to *Fungia*; our specimen is regenerating from a sector of the original corallum, which is represented by three costæ.

Genus *Ceratotrochus* Ed. & H.

C. johnsoni Duncan.

Duncan, Proc. Zool. Soc., 1882, 217, viii, 5–8.
Gardiner, Mar. Inv. S. Africa, III, 118, i, 5*a–c*, ii M (1904).

St. 106, 183–194 m., gn. m., 6 specimens, all dead.

The specimens measure 26 mm. high by calicular diameter 13 mm., 25 × 11, 18 × 11, 17 × 11, 16 × 11, 17 × 8 mm. Since death the surfaces of septa and costæ have been smoothed, but there is a close agreement save as to size in regard to which the several specimens so identified by one of us (J. S. G.) are intermediate. These also differ in a greater exsertness of the earlier septa, which character is shared by the present specimens.

There are also two dead specimens from St. 107, 421–57 m., and from St. 156, the latter evidently stuck in the net of the trawl from a previous haul.

Genus *Stephanocyathus* Seguenza.

Stephanocyathus Seguenza, Mem. Reale Acad. Sci., Torino, ser ii, XXI, 61 (1864).
Blastotrochus Ed. & H., Cor. II, 99 (1860).
Odontocyathus and *Stephanotrochus* Moseley, "Challenger" Report, 148 (1881).
Sabinotrochus Duncan, Trans. Zool. Soc. VIII, 320, xli, 6–9 (1871).

The justification for a separation of the genus from *Trochocyathus* lies in the subdiscoidal-form of growth, the other character mentioned by Seguenza, viz. bilobed pali, being represented in our suite of specimens by paliform lobes, usually single, sometimes double. Edwards and Haime's *T. obesus*,* the centre of the discoidal subgroup is obviously a young form of the genus. The other Eocene and Miocene species placed with it are less easy to understand, the extent of chemical changes in and depositions on their coralla being unknown.

In considering the genus it is especially necessary to remember that its corals were all attached and are attempting to assume a secondary subdiscoidal method of growth; in our species they break off while still thin and transparent before they have attained a quarter of the adult size. They show no variations dependent on feeding and movement, both of which are invariable, specific characters being fixed, as in all corals, independently of these functions. The septa dominate the growth of the calicles and the theca is built up of corallum deposited on the septal sides. All septa grow out at first horizontally from a base, represented later by a minute scar, but subsequently are built up vertically; all are very exsert in the adult and vary in size according to their cycles. Pali and

* 'Ann. Sci. nat.' 3e ser., IX, 313 (1848).

columella are morphologically depositions of corallum on a basal disc and as such do not exist here; growths of parts of the septa, paliform lobes, and fusion of the inner ends of the septa by trabeculæ, frequently crowned by upstanding rods or corallum, replace them. The costæ on the horizontally extending base show blunt lobes or spines, always largest around the edge. *Odontocyathus* presents an extreme development of this arrangement, which undoubtedly adds to the stability of the coral when lying on the bottom; the processes are solid and well below the polyp, so that they are not in course of growth, and their presence at most is only a specific character. Our series of specimens show that *Sabinotrochus* Duncan is a young form of the genus under consideration.

We may here refer to a cornucopia-shaped coral which was dredged with our specimens from St. 159, 914–1463 m. Within its corallum-cup it is not separable from the forms of *Stephanocyathus* from the same station, and indeed it only differs in its growth-shape and in that the septa are straighter, as in *S. platypus*, and that two pairs of septa of cycle VI are present in systems on opposite sides of the corallum. It is broken in the stalk, here being about 5 mm. in diameter and it stands up 3·6 cm. above this, the diameter of the open calicle being about the same; the costæ are small, without any of the enlargement and massiveness found on the base of *Stephanocyathus*. The thickening of the stalk by epitheca is noticeable in the broken base, but the greater part of the corallum would seem to have been covered by the living polyp. The polyp was much torn and crushed, but otherwise in its gross anatomy resembled our species below. There is no trace of any attempted assumption of a disc-shape, and its interest is mainly in respect to the relationships of *Trochocyathus* and *Stephanocyathus*. It has the shape into which the latter might be expected to grow if no horizontally extending disc were formed. There is a second partially decayed and smaller specimen from St. 157, 229 m., cr. r.

Stephanocyathus nobilis (Moseley). (Pl. VI, figs. 13 and 15.)

Stephanotrochus nobilis Moseley, "Challenger" Report, 135, iii, 3 (1881).
Stephanotrochus oldhami Alcock, J. As. Soc. Bengal, LXIII, 187 (1894).
Stephanotrochus nitens Alcock, "Investigator" Exp., 18, ii, 6 (1898).
Stephanotrochus weberianus and *sibogæ* Alcock, "Siboga" Exp., 24, iii, 22, 23 (1902).
Stephanotrochus campaniformis Marenzeller, "Valdivia" Exp. VII, 302, xviii, 20 (1904).

St. 118, 1789 m., gl. oz., 4 living, 1 having been decalcified, young.
St. 119, 1207–1463 m., 4 living, 8 dead varying from 12 to to 38 mm. diameter.
St. 152, 609–915 m., gn. s., 2 living.
St. 158, 786–1170 m., 2 living, 2 dead, young.
St. 159, 914–1463, 11 living, 7 having been cleaned.
St. 185, 2000 m., gn. m., 2 living (1 decalcified and 1 cleaned).

Adults, over 3 cm. in diameter: corallum dense and massive in appearance, varying from flat-bottomed saucer- to bowl-shape. Base rounded to quite flat, with a central scar of former attachment, 1–2 mm. in diameter, where distinct showing 4–6 septa. Base set with 12–24 coarse costæ, each with about 6 spines, which increase in size from the central scar to the periphery, where they may stand out almost horizontally, thus adding to the steadiness of the corallum on its base.

Side walls varying from about 60° to vertical in their rise from the base, generally rather hollowed out where the peripheral spines of the basal costæ are strongly projecting;

the side wall below the polyp tissue covered by a shining epithecal deposit, the polyp not extending in life more than 2–3 mm. down the outside of the thecal wall. Costæ existing here corresponding to all the septa and varying correspondingly in thickness, low, unspined and slightly to completely obliterated by the epithecal deposit.

Larger septa (I and II) varying up to 7 mm. in exsertness ; all septa standing up well above the theca, the edge of which may be even in height or rise higher between the larger septa and those next on either side. Deeper the septa sloping inwards almost vertically, thus giving an open area in the centre of the corallum, about half its diameter ; in this inside slope edges of larger septa (I and II) entire ; septal cycles III and IV complete, also about half of V, septa of cycle IV frequently bent towards and joined to those of III by trabeculæ.

Paliform lobes of septal cycle I and II usually largely merged into a columella-like mass in centre ; septa of cycle III narrower, each generally with a conspicuous tooth, these also usually found on cycle IV where V is present, sometimes double or bifid, especially on III.

Columellar area very variable, from a mass of upstanding rods a quarter the diameter of the calicle to an absence of any area except what may be due to the low paliform lobes of the septa I and II, the whole variation largely due to a secondary thickening of the corallum in this part, together with upgrowth from the trabecular junction of the septal ends.

Young forms : saucer-shaped without vertical walls, 12 spined costæ below radiating from the scar, greater part here covered over by epitheca. Septa very exsert, edges rather irregular, even in smallest (10 mm. diameter) with about half the septa of cycle IV ; those of I and II thickened and fused in the centre of the calicle, where there is a secondary deposition of corallum over the scar. Septa of cycle I distinct, cycle II often joined by the neighbouring pair of III. When about 20 mm. diameter paliform lobes distinct, but pseudo-columella not yet formed.

The method of growth in the species is such as to produce a low saucer-like disc, with upstanding septa until a size of nearly 30 mm. diameter is attained, when the polyp commences an upward growth and forms a vertical surrounding wall (theca), its deposition proceeding from the sides of the exsert septa. The polyp is seated on the top, no part of the base and only 1 or 2 mm. of the surrounding wall being clothed by the polyp tissues. The epitheca is largely dissolved off the base of adult forms, where presumably they are lying on the mud surface, and chemical changes give the formerly translucent corallum an opaque appearance. There is much variation in the deposition of the skeleton within the calicle and hence in the resulting massiveness of its appearance. The septa may be greatly thickened, especially their inner paliform parts, the appearance of a central flat columellar area being due to these or to upright pillars of varying sizes (usually with granular surfaces) arising on the solid base or on trabecular junctions between the septal ends, more often perhaps to a mixture of both. The area is broadest where the surrounding wall is vertical, becoming greatly reduced where the whole slopes in gradually, as is well seen in Moseley's type-specimen, which is only slightly more conical than one form (living) from St. 119.

The 8 dead specimens represent a series in size from 12 to 37 mm. diameter. They have lost all their translucency and are quite opaque. The epitheca has mostly disappeared, while all spines of the costæ, paliform lobes, columellar rods and all trabecular corallum is greatly reduced, being largely removed. They confirm the preceding account of the structure founded on the living coralla.

Of the species in our synonymy *S. nitens* Alcock (off Goa, 1480 m., 1 specimen) is clearly the same species; the statement that its surrounding wall is free from epitheca is almost certainly incorrect. *S. oldhami* Alcock (Laccadives, 1272 m., 1 specimen) falls within the limits of variability, especially in respect to its columellar region. Both *S. sibogæ* Alcock (E. Indies, 1301 m., 1 example) and *S. weberianus* Alcock (E. Indies, 828 m., 1 example) fall within our range. The former is supposed to be aberrant in the number of its septa, but, if the artist's figure be compared with that of the companion species, it becomes clear that there are several ways of counting the septa, the fluctuations in size of septa being correlated with growth, which here is unusually conical. *S. campaniformis* Marenzeller (South Atlantic, 981 m., 3 examples) is merely a corallum which has grown up into a rather rounded shape with reduction of columellar structures.

As to the other living species of the genus Capt. Totton lent me 5 specimens from the British Museum of *S.* (*Odontocyathus*) *coronatus** Moseley, all Atlantic, "Challenger", 390 fathoms. At the edges of their basal discs they have large costal spines, extending out horizontally in a circle, in some more marked than in Moseley's figured form; the theca above is overlaid by epitheca. As this condition seems to be general, the species must be retained.

S. platypus Moseley† (off New South Wales, 410 fms., 2 specimens dead and somewhat decayed) has a low vertical wall, the enormously exsert portions of its larger septa conspicuous, otherwise thin septa and theca. Paliform lobes are worn down, but recognizable on some septa of cycles III and IV. If decay here, as in our suite of dead *S. nobilis*, has reduced or removed costal spines, septal teeth, trabecular septal junctions and central columellar parts, these are older or less rapidly grown specimens of *S. diadema* Moseley‡ (off Pernambuco, 695 fms., and Azores, 1009 fms.). Of two Moseley specimens of *S. diadema*, the smaller has not got that septal fusion which is such a marked feature of the larger form; neither have as yet established their vertical growth. A West Indian specimen, 1200 fms., from the Agassiz Museum of *S. diadema* before us is 46 mm. diameter and is a thin transparent saucer, which has as yet scarcely commenced to grow vertically. The primary septa are separate, but septa III fuse with II, IV with III, and there is generally a line of spines representing V often fusing with IV. The large columellar area is much filled in with secondary corallum and has a rough surface. *S. discoides*‡ Moseley (off Pernambuco, 675 fms.) is probably a very young growth of the last species; as usual immature forms more closely resemble one another than do adults.

S. moseleyanus Sclater§ (Faroe Channel, 570 fms., 1 specimen living) may be regarded as a slightly older form of *S. diadema*, both being Atlantic and of the same shape, but all septa of *diadema* are joined to their neighbours of higher orders, whereas in *moseleyanus* cycle IV only join cycle III where cycle V is developed (p. 131), and this is what is also found in *nobilis*. At present we cannot assign the value to be placed for specific purposes on each structure in the coral skeleton and this is especially the case in respect to trabeculæ.

* This is supposed to be a synonym of *Trochocyathus coronatus* Pourtalès, 'Cat. Mus. Comp. Zool.' IV, 14, vi, 16 (1871), but the description is insufficient and the specimen was dead and bad.

† '"Challenger" Report,' pp. 151–155 (1881).

‡ '"Challenger" Report,' pp. 151–155 (1881).

§ 'Proc. Zool. Soc.,' 1886, 128, xii–xiv.

Indeed, we are led to wonder whether all the above forms do not in reality belong to a single cosmopolitan species.

S. explanans Marenzeller* (off S. Africa, 231 and 507 fms., a short suite of specimens shown in the figures) is smaller than *S. nobilis* and its septa are less exsert. Its basal disc shows 6 equal costæ instead of 12, but in all other characters it seems to fluctuate as the forms of *nobilis* before us.

Odontocyathus sexradiis and *stella* Alcock† (East Indies, 469 m., 1, and 411 m., 1 dead and broken) almost certainly represent the same species. They are dominated by 6 primary costæ growing out from the edge of the disc as spines, on which the corallum stands. Allied here must be *Stephanotrochus spiniger* Marenzeller‡ (Japan Seas, no depths).

The polyps of all our preserved specimens were shrunken, but similarly coloured. The outside wall varied from a dark purple-brown to a light tinge; next a pale blue ring close to the tentacles, which were deep blue and semi-transparent. The oval disc was dark purple-brown, with a narrow pale blue rim round the circular and open stomodæum. The tentacles over the septal ends corresponded in number and size with the same.

Capt. Totton has also placed in our hands a specimen 40 mm. in diameter from Timor Sea, 900 fms., presented to the British Museum by the Eastern Telegraph Co.; it was apparently recently dead. The rather pointed base was greatly decayed, epitheca dissolved away, as well as part of the theca and all costal ridges. All the inner parts of the calicle are very smooth, septa untoothed save for single paliform lobes belonging to septa I, II and III, those of I and II with some upstanding rods forming the columella. The septa are less exsert than in any specimens of *S. nobilis*, but it does not appear to us beyond the range of that species.

Genus *Sphenotrochus* Ed. & H.

Sphenotrochus intermedius (Munster).

Duncan, Trans. Zool. Soc. VIII, 320, xli, 1–5 (1873).

Four coralla of different sizes from St. 178, 91 m., c. gn. s., are identical with the description of the specimen so identified by Duncan save that the columella is a single plate, dented in the centre. The largest specimen is 5 mm. long, and the length of the calicular opening 4 mm. by 2 mm. broad.

Genus *Tropidocyathus*.

Ed. & H., Ann. Sc. nat. ser. 3, IX, 326 (1848); Cor. II, 57 (1860).

The genus was founded for *Flabellum lessonii* Michelin, and in the 'Histoire' *T. bougainvillei* was described. Duncan§ called *Tropidocyathus* a subgenus of *Trochocyathus*, and we suppose the "basal expansion" of the corallum to refer to the "bordure cariniforme". *Thecocyathus*, also made a subgenus, is quite distinct, possessing an epitheca. Pending the revision of the family we regard all three as genera, defining

* '"Valdivia" Exp.,' VII, 304, xviii, 19 (1904).
† '"Siboga" Exp.,' 24, iii, 20, 21 (1902).
‡ 'Ann. K. Nat. Hof.' Wien, III, 20 (1888).
§ 'Journ. Linn. Soc.' XVIII, 22 (1884).

Tropidocyathus as free, compressed, no epitheca, outside covered evenly by costæ, pali before all septa except last cycle, and columella of twisted rods.

Tropidocyathus lessonii Michelin* has "une forte bordure cariniforme "† or "lateral costæ expanded to form a pair of wings",‡ somewhat in the manner seen in *Platytrochus* and this is the only difference from *nascornatus*. This remark also applies to *T. bougainvillei* Ed. & H. *Trochocyathus pileus* Alcock§ differs from our species only in absence of regular asexual reproduction, the septa of cycle IV frequently joining to those of III.

Tropidocyathus nascornatus n. sp. (Pl. V, fig. 10.)

St. 104, 207, m., gr. gy. s., 3 in spirit.
St. 105B, 238–293 m., gn. m., 27 dry, 10 in spirit.
St. 106, 183–194 m., gn. m., 26 dry, 21 in spirit.
St. 107, 421–457 m., 1 dry. Total 88 ; all living when obtained.

All the coralla pale orange in colour. Primarily shaped coralla—few in number in a suite of 88 specimens—compressed cones with the septa and theca standing up slightly higher at the centre than the ends ; at each end an especially high costa of cycle I. Whole corallum completely covered by polyp-tissues, and hence no epitheca and no clearly recognizable scars or indication of former attachment.

Secondary coralla—over 90%—regenerated individuals, mostly grown from vertically split-up fragments from any part of the primary form, the smallest such pieces with about 8 septa ; many fragments transversely broken as well when the regenerated coralla grow out on all sides, the new polyps utilizing the original costæ, septa and mesenteries. Shape of regenerated corallum always endeavouring to approximate to that of a compressed cone, but necessarily great irregularity, especially in the basal region and in the shape of the calicular opening.

Costæ completely covering the whole outer surface, equal in size, finely granular, with saw-like edges.

Septa : cycles I–IV complete ; terminal septa belonging to cycle I ; between these terminal septa and neighbouring septa of cycle II septa of V commonly present, often complete in these half systems. Septa of I and II equal, broader, thicker and markedly exsert, those of II standing up higher than of IV and the thecal edge between correspondingly higher. Septal edges not toothed, sides with distinctly spined lines of growth leading to their edges, whole looking echinulate on surface view into the calicle.

Paliform structures of I and II small and frequently not distinct from columella ; those of III and often IV, when present, conspicuous flattened plates.

Columella upstanding rods, tending to be flattened along the length of the central valley, the bottom of which is commonly about 5 mm. below the upstanding sides of the corallum. In secondary coralla the whole often more open, broader columella, finer rods, highly variable with form of growth.

Largest flattened cone 20 mm. high, calicle 11 mm. broad by 16 mm. long ; mostly much smaller.

* 'Revue Zool.' 119 (1842).
† Ed. & H., 'Ann. Sc. Nat.' ser. 3, IX, 326 (1848).
‡ Alcock, '"Siboga" Exp.' 37 (1902).
§ *Loc. cit.* 15 (1902).

This species differs from all others of the genus in its extraordinary method of asexual reproduction, the coralla breaking up and its pieces regenerating polyps and coralla. With a large suite of specimens before us we cannot regard this as an accidental phenomenon. Pourtalès* briefly referred to a similar method in *Leptocyathus stimpsonii*, nov., from 60 fms., West Indies, and figured one regenerated specimen; the species here is a circular, more or less discoidal or cup-shaped form, with subequal toothed septa, pali II prominent.

Tropidocyathus lessoni (Michelin).

Michelin, Revue Zool. p. 119 (1842); Magaz. de Zool. pl. 6 and description (1843); Ed. & H., Ann. des Sci. nat. 3e ser., IX, 327 (1848).
Alcock, "Siboga" Exp., 17, ii, 14*a* (1902).

There are 4 specimens of this species from St. 103, 101 m., c. s. sh., which agree with the above, the largest about the size of Michelin's specimen, which was 10 mm. high, calicle 10 by 6 mm.; wings and columella agree with his figure. Alcock's Siboga specimen is figured with a flattened columella divided into three, not the "papillose" type, but we think it is a rather older corallum.

Genus *Discotrochus* Ed. & H.

Discotrochus dentatus Alcock.

"Siboga" Exp., 27, iv, 26 (1902).

St. 89, 193 m., s. sh. r., 1 dead.
St. 145E, 494 m., 3 living.
St. 149, 238 m., cr. r. lth., 1 living.
St. 157, 229 m., cr. r., 1 living and 2 dead.

All specimens have a distinct scar of attachment 2–3 mm. across, subsequently overgrown by the polyp-tissues. Living specimens show the corallum translucent, but thick, while in dead specimens it is opaque and thus appears to be thickened in septa and costæ, and at the thecal edge; this adds to the coarse look of the already relatively massive skeleton. Alcock's figure is distinctly that of a dead specimen, the living forms having more differentiation of septa and of costæ, and their outer ends over the theca are more exsert. The columella varies considerably from a smaller number of larger rods than shown in Alcock's figure to an area looking lightly packed with coarse grains. The diameters of the disc of the largest living and dead forms are 20 mm. and 23 mm.

The species described by Alcock as *D. investigatoris*† was obviously founded on a young and dead corallum which had been chemically altered as above; it probably belongs to this species, but, as this cannot ever be determined, unless a long series is collected, it had better disappear from literature.

Genus *Deltocyathus* Ed. & H.

The genus is well marked, a chief and unalterable character being the fact that the corallum was deposited entirely within the polyp, which is not known ever to have

* 'Cat. Mus. Comp. Zool.' IV, 12, iii, 1–3 (1871).
† 'J. As. Bengal.' LXII, 142, v, 5 (1893).

been attached in the mode of *Fungia*. All authors who have described its species agree as to this except Lindstrom,* who assumes a former attachment. This question is difficult, because without attachment or some invagination at the base of the young polyps, it is hard to understand how the ectoderm-formed corallum can have originated. We have many small specimens before us, especially of *D. minutus* nov, and one of us (J. S. G.) has examined others in respect to this question both at the Smithsonian Institute and the Agassiz Museum of Zoology ; unfortunately they are devoid of polyps.

So far as we can judge the septal growth dominates in development, the thecal part formed by thickenings on the septal sides ; this theca causes one part of the radiating plates to be called septal and another costal. Clearly all septal " fusions " must be ectodermal outgrowths from the earlier cycles at right angles to the individual septa, meeting similar outgrowths on the later cycles when formed. On this plan pali and columella, which should grow up on a basal plate, cannot exist—and indeed all such appearances in the species we have before us are equally well described as paliform lobes of septa. We state the morphological problem in the hope that one day it may be solved by a study of development ; there must have been an early invagination to produce the corallum.

Whilst there is no trace of a basal scar in the majority of our specimens, we are confronted with a few amongst our *D. andamanicus* in which may be imagined a faint trace of a possible basal attachment. In some this part of the corallum is masked by chemical changes that inevitably occur in any dead part of the corallum. In any case it is unnecessary to assume the formation of a basal plate of attachment, an epithecal formation, especially since Noboru Abe's study of the " Post-larval Development of *Fungia actiniformis* ", wherein he shows that 6 endosepta begin to form within the planula on the seventh day after extrusion from the mother and that there is no suggestion of any further coral structures until the seventeenth day.†

As to the species, it is clearly useless to describe the same without a suite of specimens, and we apply this to *D. ornatus* Gardiner.‡ The type-species of the genus is *D. italicus* (Mich.) from the miocene, and into this Pourtalès subsequently absorbed his *D. agassizii*. Moseley's " Challenger " specimens§ from the Indo-Pacific cannot be accepted as *D. italicus*, one being attached and the other considered as doubtful by Moseley ; neither of these specimens are in the British Museum and are probably non-existent. Alcock|| identifies 5 specimens from the East Indies (204–794 m.) as *italicus*, but does not discuss its relationship to *andamanicus* ; he gives full references—and also to its synonym *D. agassizii* Pourtalès. We feel uncertain whether the living species is identical with *italicus* or should more properly be termed *agassizii*. We have not the advantage of " 1000 specimens " from one locality (West Indies) for study, as Pourtalès had, and must hence accept his species with its three or four forms of growth. Of 9 specimens before us from the West Indies, 4 belong to var. α, 2 to var. β, and 3 to var. δ. They would be regarded as distinct species had we not the assurance otherwise of Pourtalès.

* ' K. Sven. Vet. Akad.' XIV, 10 (1877).

† ' Palao. Biol. Sta.' I, 73–93, 1937. The growth curve of this larva shows a rapid rise in the first six days, slowing rapidly as soon as the skeleton commences to form.

‡ Willey's ' Zoological Results,' II, 163, xx, 25 (1899).

§ ' " Siboga " Exp.' p. 19 (1902).

|| ' " Challenger " Rep.' 147 (1881).

Deltocyathus andamanicus Alcock.

"Investigator" Report, 16, i, 5, 5*a* (1898); Vaughan, U.S. Nat. Mus., Bull. 59, 71, vi, 4, 4*a* (1907).

St. 119, 1207–1463 m., 2 living.
St. 149, 238 m., cr. r. lth., 5 living.
St. 180, 397 m., gn. m. s., 6 living.

Our series vary up to 15 mm. in diameter and are much less massive, though larger than any West Indian *italicus* that we have seen. For the species before us we have Vaughan's support from actual comparison with *italicus*, for he remarks "no evidence of intergradation was found".

The costæ do not meet in a point on the underside of the disc in adult forms, but run into a small rounded area covered with minute spines. There is no justification for regarding this in our specimens as the scar of a former adherence which it may superficially resemble. This view is supported in that 6 small forms of about 3 mm. diameter, St. 180, have no scar, assuming that they are correctly ascribed. The pali or paliform lobes are not well marked in these young specimens.

The septa are much thicker and more even than in *D. murrayi* nov. or *rotulus* (Alcock).

Deltocyathus rotulus (Alcock).

Trochocyathus rotulus Alcock, "Investigator" Rep. 16, vi, 1, 1*a* (1898).
Deltocyathus fragilis Alcock, "Siboga" Exp. 21, ii, 15 (1902).

St. 26, 2312 m., sft. gy. w. m., 1 dead.
St. 34, 1022 m., gn. m., 1 dead.
St. 119, 1207–1463, 4 living, 3 dead.
St. 145, 510 m., 3 living.

Alcock's descriptions and figures are excellent and apply well to our 7 living specimens, but why he placed them in two genera and two species we cannot conceive. The points from which the costæ radiate on the undersides of the discs are white and opaque, apparently killed where they lay on the bottom; there is no trace of former adherence. The symmetrically-scalloped edge to the theca and a certain irregularity in height of the same is a most conspicuous feature, showing the formation of the theca by septal thickenings.

The exsert ends of the septa are not nearly so prominent as in *D. murrayi* n. sp., to which the species in texture bears a close resemblance. Alcock's description of the 18 principal and 54 other septa is accurate for the larger forms, but our dead specimens enable us to see that this is a growth feature, 24 septa of cycle V not being formed. The 18 paliform lobes of the larger septa are conspicuous and long.

The columella is as described, but in one of our specimens, owing to the thickening of the upstanding ends of the trabeculæ, looks papilliform.

We consider that *D. fragilis* was a specimen of *D. rotulus* that had died recently; for in all features Alcock's figure and description of *D. fragilis* agrees with our dead specimens, except in the thin vitreous texture of the corallum. In all our dead specimens surface chemical deposition was considerable.

Deltocyathus murrayi n. sp. (Pl. VII, fig. 16; Text-fig. 3.)

St. 26, 2312 m., sft. gy. w. m., 10 living and 3 dead.
St. 59, 1948 m., sft. gn. m., 1 dead.
St. 185, 2000 m., gn. m., 2 living and 5 dead.

Corallum of a thin vitreous texture, discoid to saucer-shaped, round or slightly oval. Thecal edge regular without indentations, crossed by the septal edges, the 12 larger septa extending horizontally for 2 mm. beyond the theca. Costæ thin, 12 prominent

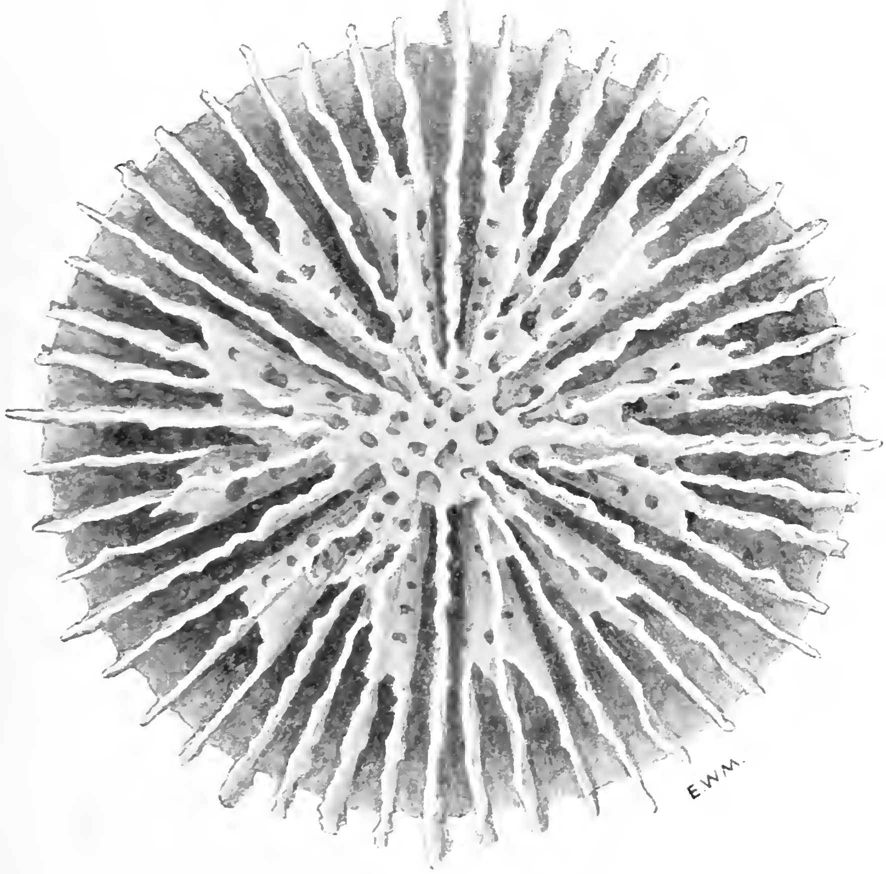

FIG. 3.—*Deltocyathus murrayi* n. s.p. × 6.

and relatively high, extending to a central point, with others of the third and fourth cycles, similar but lower and not reaching the centre; edges of all finely toothed.

Septa: four cycles of the regular generic character, viz. cycle I separate reaching the centre, cycle IV joined to III and III to II; all remarkably thin, irregularly serrated on their edges, with growth-lines as ridges on their faces.

Paliform lobes elongated, rather variable in size, but always thin and at internal ends of septa I–III, each marked off by a notch, best viewed at an angle of 45°.

Columellar region: trabeculæ joining the septa together to form a spongy mass, with low twisted upstanding processes, the whole broadening with a more completely discoidal nature of the whole corallum.

Size varying up to 21 mm. diameter.

None of the specimens has any trace of any former basal attachment; this is perhaps correlated with the muddy bottom on which they lay. On their upper surfaces they likewise show no distortion and in consequence a complete regularity of septa. There is no filling-up of the corallum between the septa, and any thickening of theca and septa, subsequent to their formation, is very slight. In large specimens, septa of cycle I stand up for 3–4 mm. above the theca, and there is a certain irregular appearance which helps to separate the species from *D. rotulus* (Alcock).

Deltocyathus lens Alcock. (Text-fig. 4.)

"Siboga" Exp., 19, ii, 16 (1902).

St. 104, 207 m., gr. gy. s., 11 mostly alive.
St. 126, 209 m., lt. br. m. sh., 1 alive.

These agree in all respects with this species, which in shape is much less discoid than most species of the genus. None of the specimens, including a baby of less than 2 mm. —the largest is 8 mm. across—show any trace of former adherence Since the paliform lobes are shown as too massive in Alcock's figure and those internal to septa III are not represented, an additional figure may be helpful. One of our specimens seems to be the regrowth of a sector of a disc which split up from the centre, as *Diaseris* does.

Alcock states: "Costæ all equal and all distinct from calicle to base, sharply salient and elegantly serrulate." There is a certain difference in exsertness of the different cycles of septa in his figure, and the costæ of our specimens corresponding to septa I and II are more prominent and thicker.

Deltocyathus minutus n. sp. (Text-fig. 5.)

St. 7, 300 m., sft. y. m., 23 specimens, alive but much damaged by mud.
St. 103, 101 m., c. s. sh., 1 dead.
St. 206, 256 m., gr. br. s. m. r., 33 specimens, all alive when obtained.
St. 209, 366 m., gr. br. m. r., 1 living.

Corallum a flattened disc when young, thickening almost to an inverted dome-shape, which is correlated with the growth of septa. General appearance dense, almost massive. Undersurface with no trace of former adherence, central part smooth and rather solid. Costæ low, thick, covered by granules and very even in size.

Septa: Equally and slightly exsert over the theca, where they pass into the costæ; in smaller specimens cycles I, II, III only, III joining II; in larger forms never more than half the septa of IV found; all relatively thick and granulated with narrow interseptal loculi; all evenly upstanding on the peripheral half of disc.

Pali (or paliform lobes) rather low, very varied, from quite distinct at inner ends of septa II and perhaps some low before septa III, where IV present, to scarcely distinguishable pillars.

Columella relatively small, a few rods often placed as if having a paliform connection with septa I.

Size 1·2–5 mm. diameter.

Deltocyathus varians n. sp. (Pl. VI, fig. 14 ; Text-fig. 6.)

St. 176, 655–732 m., gn. m. s., 1 complete corallum, 1 nearly so, 2 halves and 1 piece.

Corallum discoid with no sign of former attachment tending to be curved up at the edges, with total height varying up to 5 mm., whole tending to split from the centre with subsequent regeneration.

Costæ radiating from a central point, well marked and rather thin ridges, with granular edges ; quite distinct and clearly defined sizes corresponding to cycles of septa.

Thecal edge irregular, extending further between the exsert ends of the larger septa and those next to the same. Septa 12 reaching to the central hollow ; between each of these a septum extending equally far in with a pair of septa converging and fusing to same

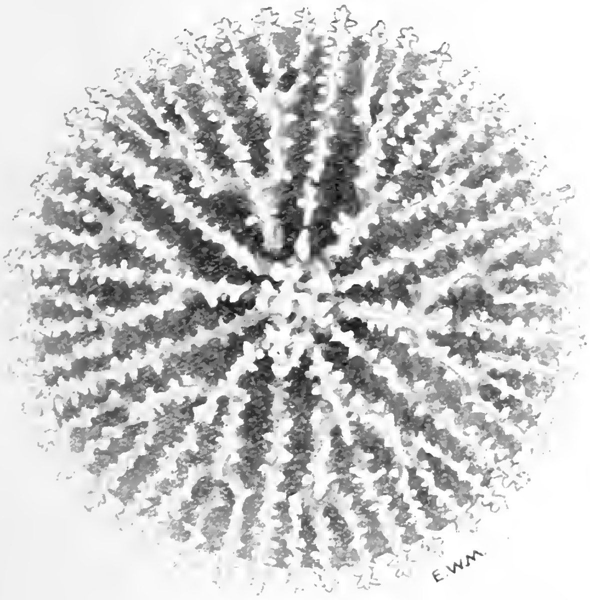

Fig. 4.—*Deltocyathus lens* Alcock. × 12.

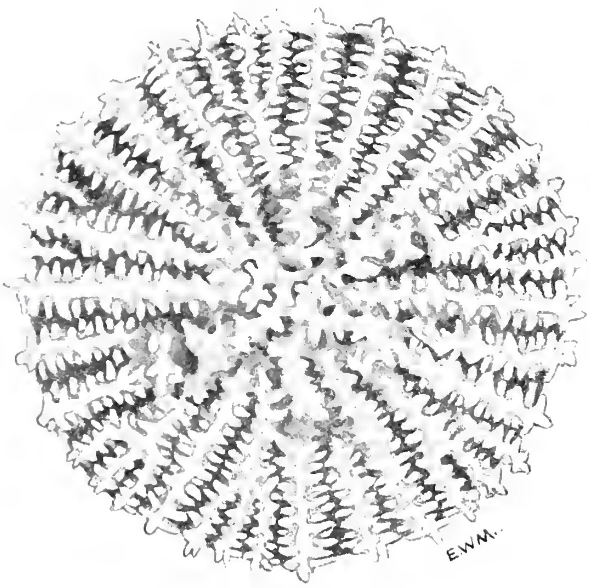

Fig. 5.—*Deltocyathus minutus* n. sp. × 25.

in the outer half of each radius, the central member of each such group belonging to the most exsert series of septa and having the largest costæ, these septa generally having a flattened upstanding tooth just internal to the septal fusions.

No well-defined pali and no true columella, but in place a number of fine teeth, on the central parts of the septa or on trabeculæ from the same, giving a mass of fine rods.

Size up to 14 mm. diameter.

We might describe this coral as having 12 septa (I and II), then 12 (III) with chevrons produced by fusions with septa IV—these are more peripheral than in many species of *Deltocyathus*—and a flattened tooth internal to the same. Then the mass of fine rods in the centre would be supposed to include pali of I and II. The splitting-up and regeneration of the disc has not previously been described in the genus and is the main justification for suggesting a name on material admittedly inadequate. The actual parts of the corallum are firmer and thicker than in *Fungiacyathus*,* but this may be partially a matter of the depth in which the coral lived.

* *Vide* p. 200.

Genus *Fungiacyathus* Sars.

G. O. Sars, Remarkable Forms of Animal Life, Christiania, 58, v, 24–32 (1872).

This genus appears to us to be a turbinolid. Its types, however, bear a resemblance to *Fungia*, but show no trace of its early development. These were four specimens obtained by the elder Sars from 300 fathoms off soft clay on the Norwegian coast, and three are illustrated by his son. All these are irregular in outline, and this character is only to be understood on the view that they represent discs that have regenerated from pieces of the split-up corallum as seen in " *Diaseris* ", or in another shape in the *Tropidocyathus*

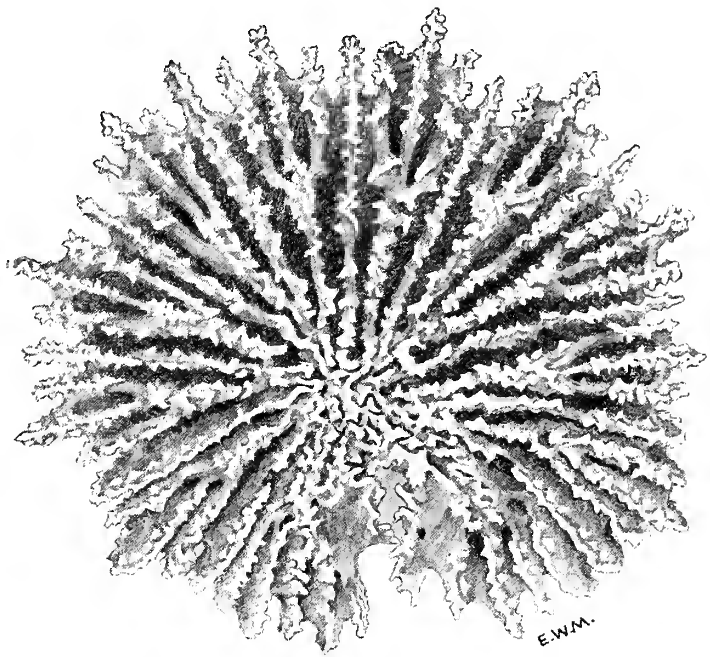

FIG. 6.—*Deltocyathus varians* n.sp. × 6.

nascornatus described in this report, the same specific designation being equally appropriate below.

The Director of the Museum at Oslo kindly lent us the fourth and largest specimen of the type-species, *F. fragilis*, which had been preserved in spirit ; it proved the excellence of Sars' description. Synapticular junctions do not seem to be present between the septa, so that it represents a genus apart from *Bathyactis*, although it resembles the latter in its thin corallum. The specimen consists of three pieces of a single disc of about equal size, now held together solely by the polyp-tissues ; indeed, it was in process of splitting up to form three coralla. Its flat, thin and light skeleton separates it from the species now described as new.

The descriptions of two supposedly new species, which follow, are short, the figures being integral parts of their descriptions. The coralla of these species are imperforate, their interseptal spaces completely open to the base, with little or no deposition of corallum on the theca after it has been formed. The septa neither bend towards each other nor fuse, and there is the minimal trabecular formation in all parts.

Fungiacyathus nascornatus n. sp. (Pl. VII, figs. 19, 20.)

St. 176, 655–732 m., gn. m. s., 4 and 3 pieces.
St. 185, 2000 m., gn. m., 4 and 2 pieces.
St. 72, 73 m., c. s. sh., 2 pieces.

Corallum evidently somewhat discoid when young and free, then splitting up from the centre outwards, each piece regenerating a calicle, which tends to grow upward, becoming cup-shaped, though always spreading outwards. Whole enclosed in the polyp-tissues. No evidence of former adherence.

Costæ granular, rather thick and even, though cycles may be distinguished.

Septa varying up to 2 mm. exsert and rising up to 4 or 5 mm. above the theca, in different systems up to 4 cycles, no fusion of septa of lower to higher orders ; growth-lines and a certain spinulose character on the septal sides with edges tending to be wavy.

No pali and no columella, but in the regeneration of the central part of the corallum fine trabeculæ tending to grow upwards as fine curled rods.

Size up to 25 mm. in diameter.

The above description has been founded on the specimens from St. 176. Those from St. 185 are of half the size, their coralla more delicate, all dead below where mud-covered and tending to assume an open cup-shape with consequent variation in the septa. That from St. 72 is a half corallum of small size, rather more massive than last.

Fungiacyathus sarsi n. sp. (Pl. VII, figs. 18, 19.)

St. 141, 44 m., c. s. sh. cr., 6 living.

Corallum discoid and flat, almost circular, frequently splitting from the centre outwards and regenerating almost flat discs. Whole corallum enclosed within the polyp, without evidence of former adherence.

Costæ thin, even, low ridges radiating from the centre, cycles mainly traceable from the exsert septal ends.

Septal cycles difficult to distinguish, up to 24 larger and about 1 mm. more exsert, rather irregular, all joined by a thin imperforate theca ; usually three between neighbouring larger septa, last cycle very distinctly lower and thinner ; on account of mode of growth edges of septa zigzag ; all except last size running into the central space with a series of low spines filling the same.

Sizes varying from 13·5 to 17 mm. in diameter.

All the specimens would appear to have been regenerated coralla and hence might not show any traces of former adherence. They are much stronger and firmer coralla than *nascornatus*, but unfortunately the polyp-tissues of both species were destroyed by the sand or mud which was brought up with them. All specimens are figured; the regenerated part of one is curiously open in the centre.

VI. CLASSIFICATORY TABLE OF THE SIMPLE TURBINOLIDÆ HAVING SPECIES STILL LIVING.

TURBINOLIDÆ Wall thecal; septal loculi open to base; simple corallum	tall or conical; columella	absent; the pali	absent		*Desmophyllum.*
			1 crown		*Conocyathus.**
		twisted ribbons; pali	1 crown		*Caryophyllia.*
		fascicular; pali	2 crowns		*Trochocyathus.*
			before all septa except last cycle; corallum	fixed	*Paracyathus.*
				compressed, free	*Tropidocyathus.*
			absent; free		*Ceratotrochus.*
		lamellar; pali absent; free			*Sphenotrochus.*
	broad; free or attached shell, often with *Aspidosiphon*; pali before all cycles.				*Heterocyathus.*
	discoid or saucer-shaped; pali	well developed; septa	penultimate bending towards next highest cycle		*Stephanocyathus.*†
			of last two cycles deltoid		*Deltocyathus.*
		absent; septa	straight with thick blunt teeth		*Discotrochus.*
			straight and untoothed		*Fungiacyathus.*

(In the above Table all the genera in the adult state from *Tropidocyathus* downwards are unattached; this we regard as a secondary character and not indicative of the past evolution.)

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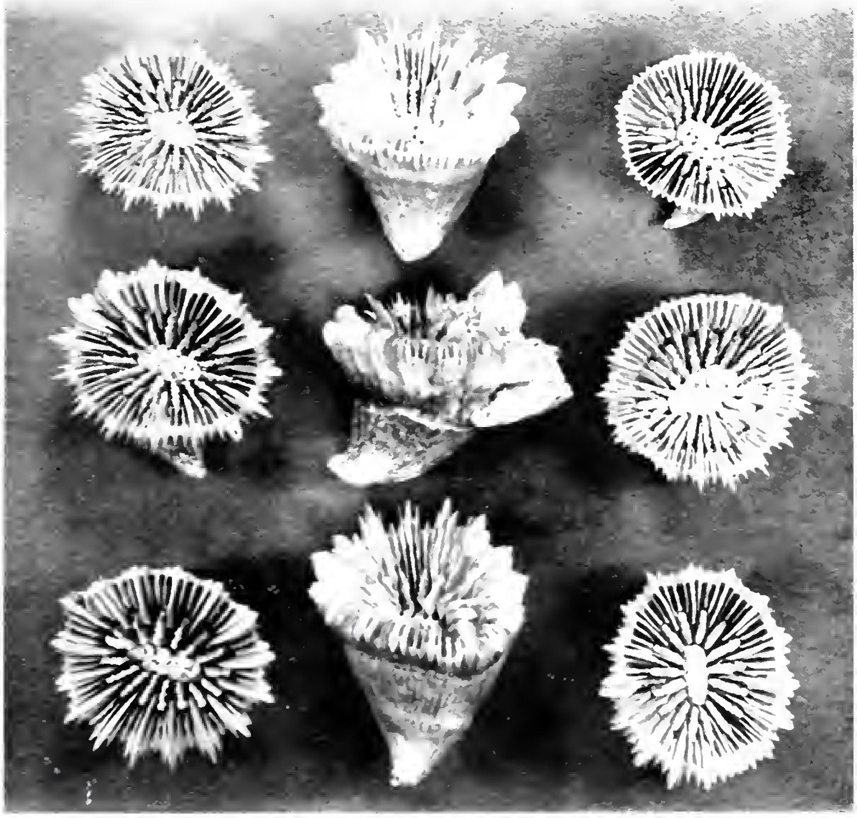
* We have not had the privilege of examining this genus, a living species of which is figured by Duncan in 'Proc. Zool. Soc.,' 1876, 431, xxxviii, 1–3, locality New Zealand. Harrison, 'Proc. Zool. Soc.,' 1911, 1031, refers this species to *Trematotrochus*, to which he gives references; assuming Duncan's description to be correct, we doubt this identification and the reference of the genus to the Turbinolidae.

† Gravier ('Res. Camp. Sci., Monaco,' LV, 1920) under name *Stephanotrochus* should be consulted, his beautiful figures of this and other genera examined. We have not discussed his report in our text, differing from him in method of approach and having a strong objection to growth-varieties. Someone will perhaps examine the British Museum and Monaco specimens together. Gravier's genus *Peponocyathus* should perhaps be inserted in the table above, but we have not examined it. Its coralla are of a peculiar gourd-shape, straight septa, pali, etc., and are clearly related to *Deltocyathus*.

DESCRIPTION OF PLATE I.

Fig. 1.—*Caryophyllia clavus* Scacchi. × 1.

Fig. 2.— ,, *grandis* n. sp. × 1.



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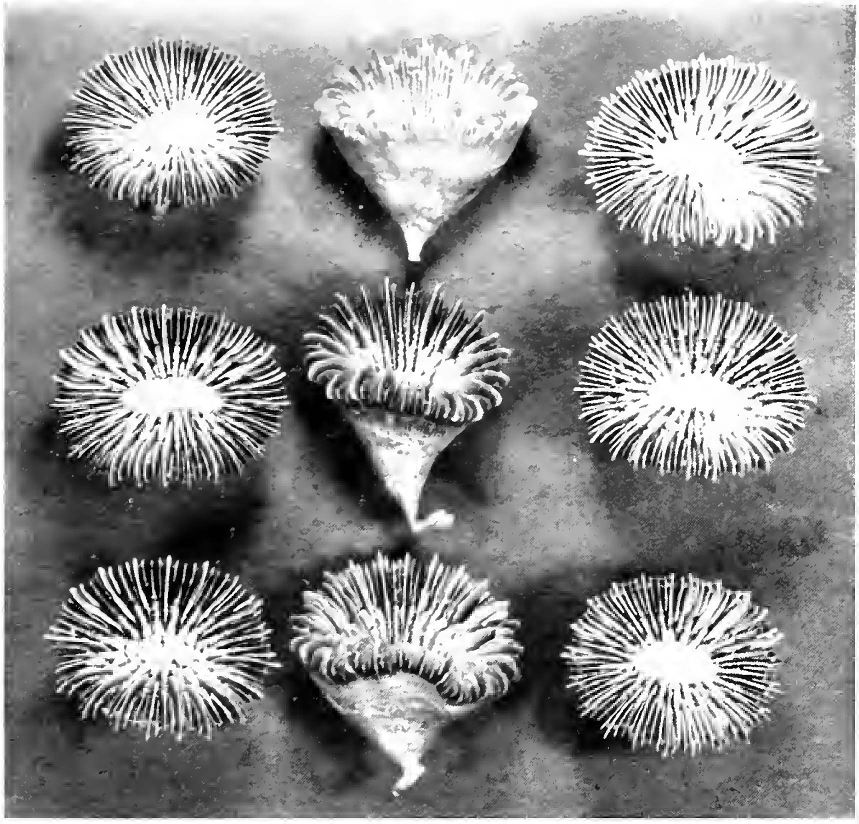

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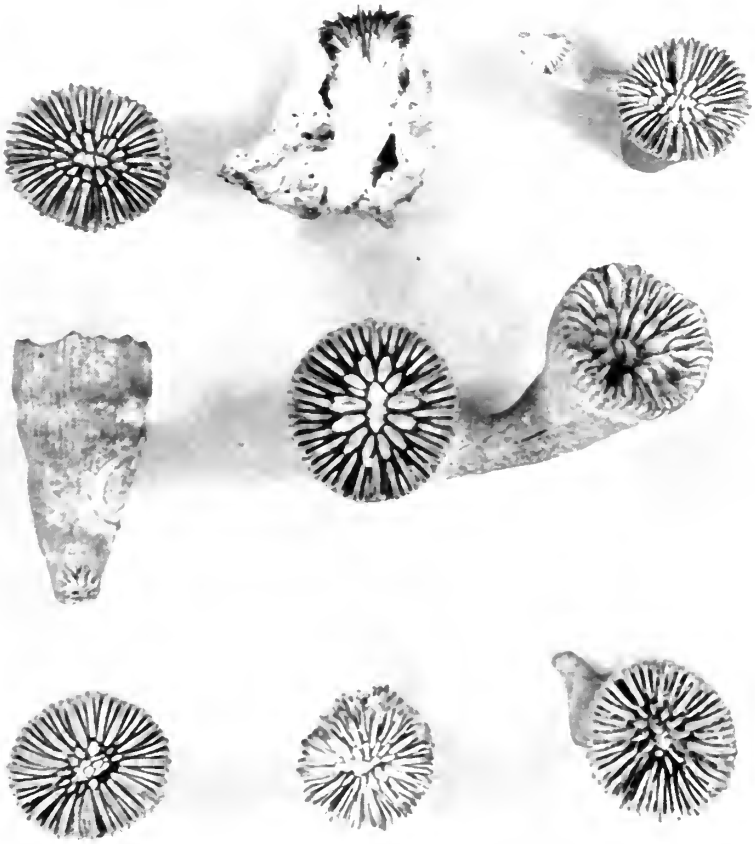
DESCRIPTION OF PLATE II.

FIG. 3.—*Caryophyllia sewelli* n. sp. × 1·25. The central coralla top and bottom were alive when obtained.

FIG. 4.— ,, *compressa* n. sp. × 1·25.



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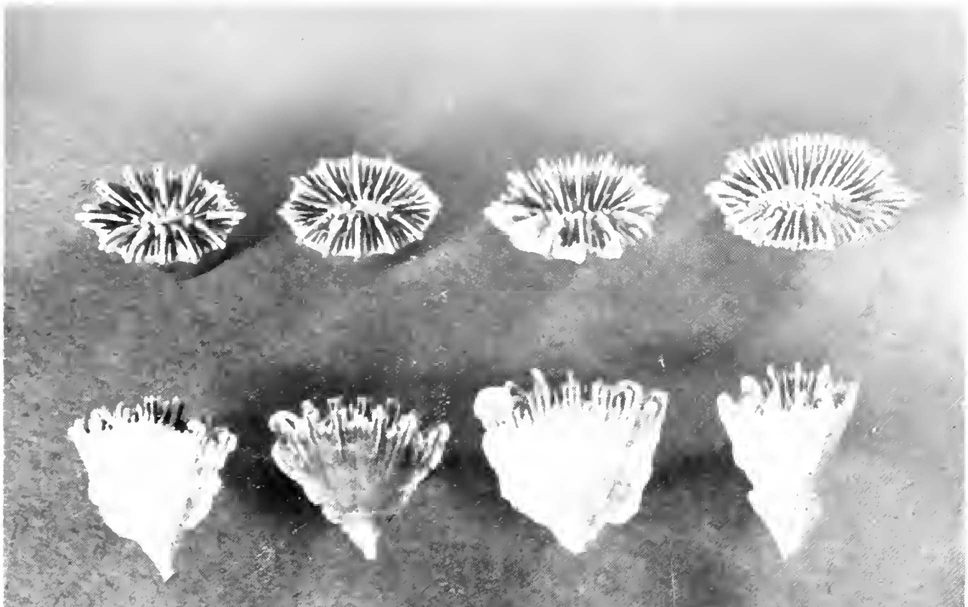

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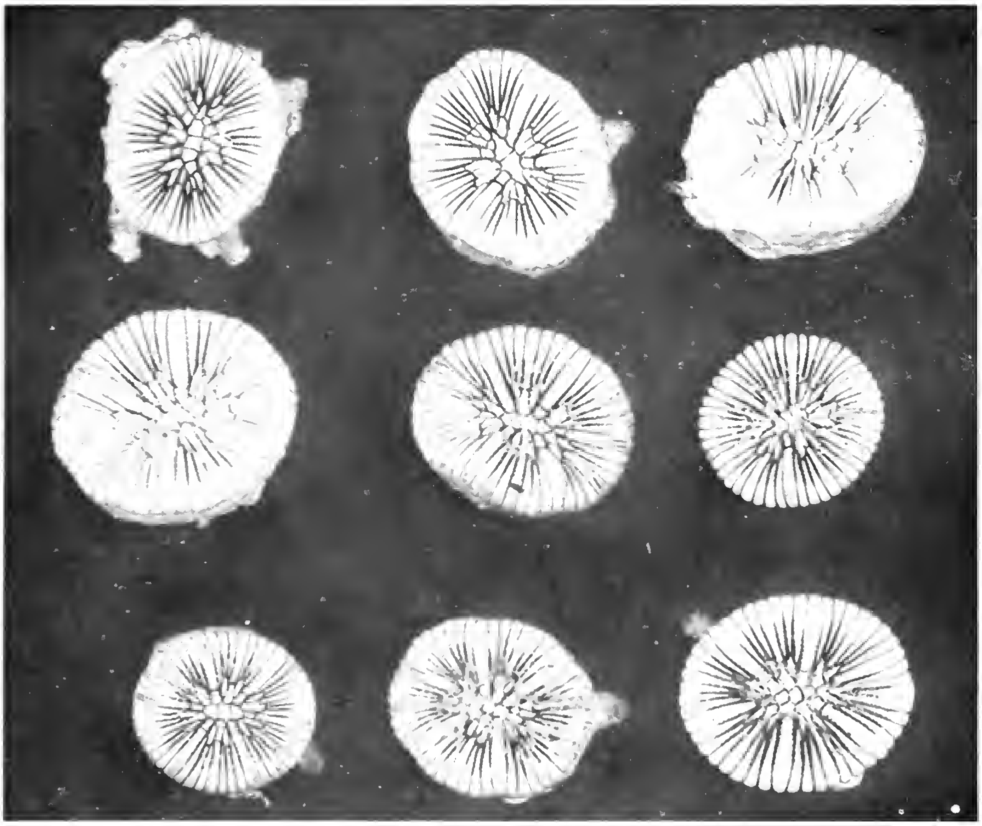
DESCRIPTION OF PLATE III.

Fig. 5.—*Paracyathus gardineri* Vaughan. × 2·4.
Fig. 6.—*Caryophyllia mabahithi* n. sp. × 1·3.
Fig. 7.— ,, *scobinosa* Alcock. × 1.



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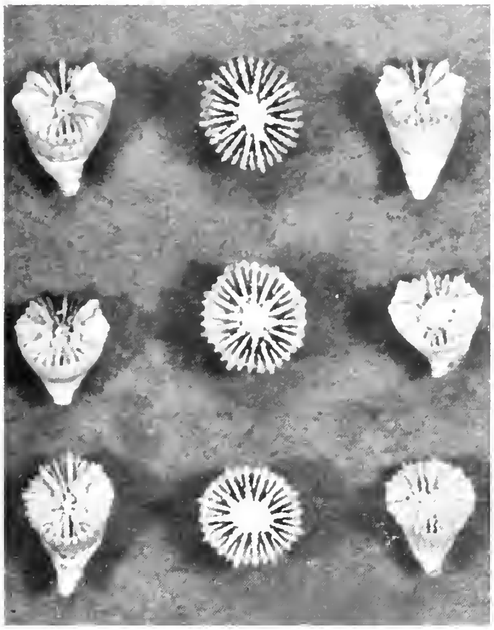

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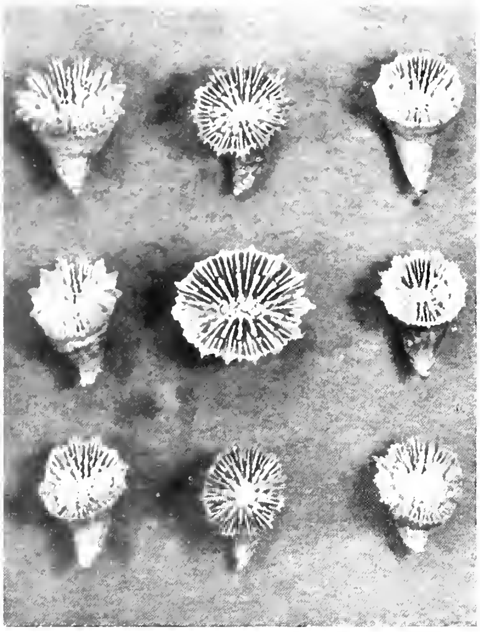

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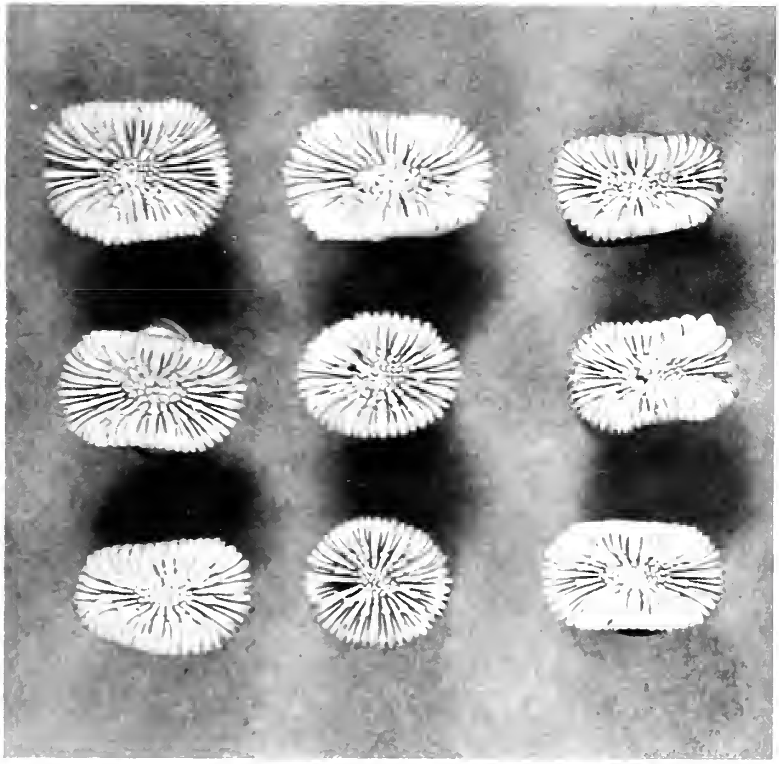
DESCRIPTION OF PLATE IV.

Figs. 8 and 9.—*Paracyathus conceptus* n. sp.

(Fig. 8 magnified and Fig. 9 reduced; see measurements in text.)



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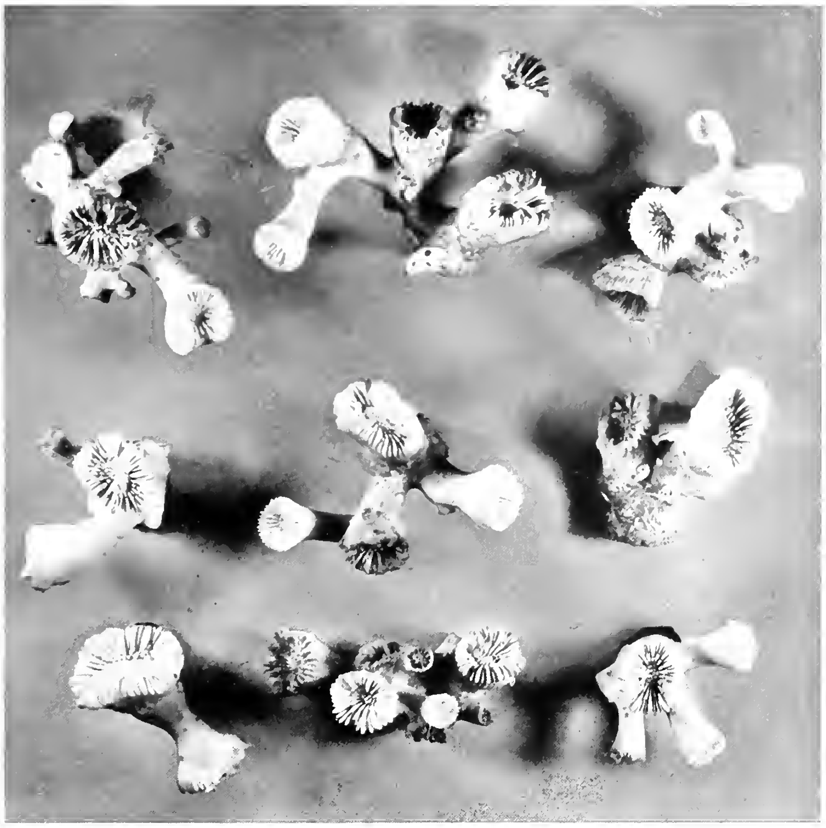

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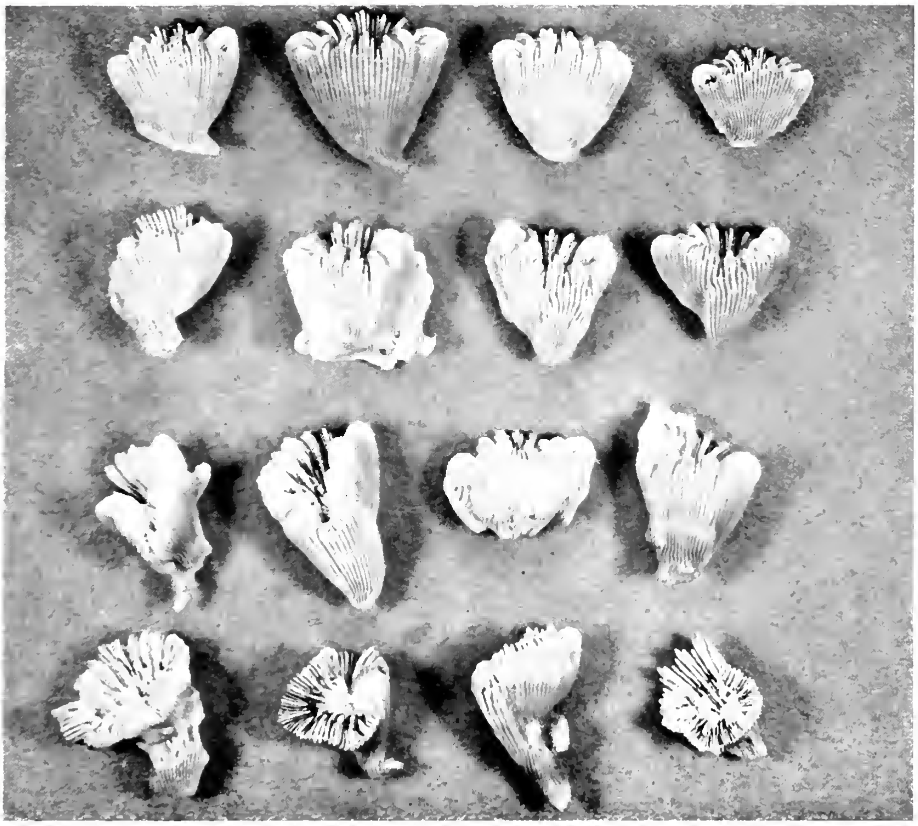
DESCRIPTION OF PLATE V.

FIG. 10.—*Tropidocyathus nascornatus* n. sp. Slightly magnified.

FIGS. 11 and 12.—*Conotrochus brunneus* Moseley. × 1·3.



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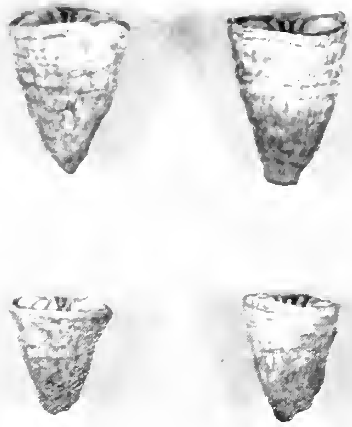

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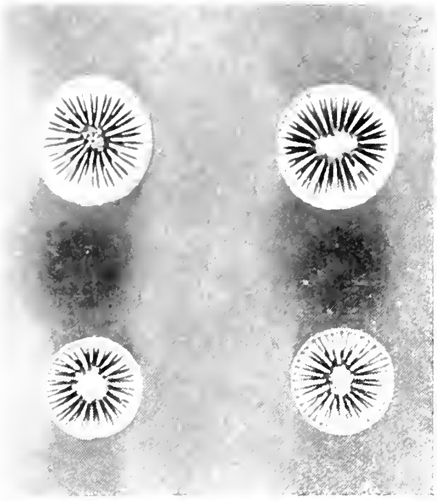

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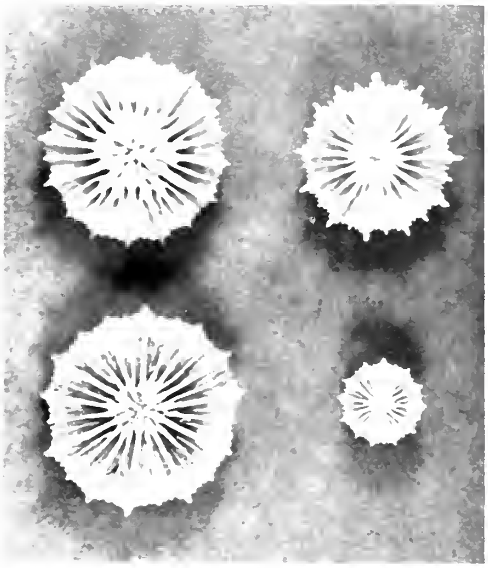
DESCRIPTION OF PLATE VI.

FIG. 13.—*Stephanocyathus nobilis* Moseley. × 1·4. Young forms, that to south-east St. 152, rest from St. 118.

FIG. 14.—*Deltocyathus varians* n. sp. × 1·2. The specimen to north-west is shown in Text-fig. 6.

FIG. 15.—*Stephanocyathus nobilis* Moseley. × 0·8. Adults.



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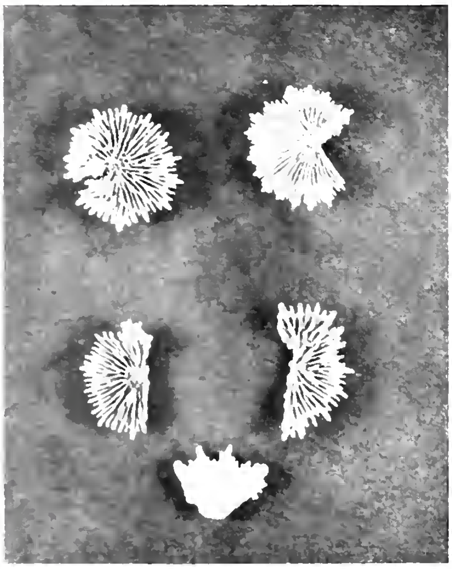

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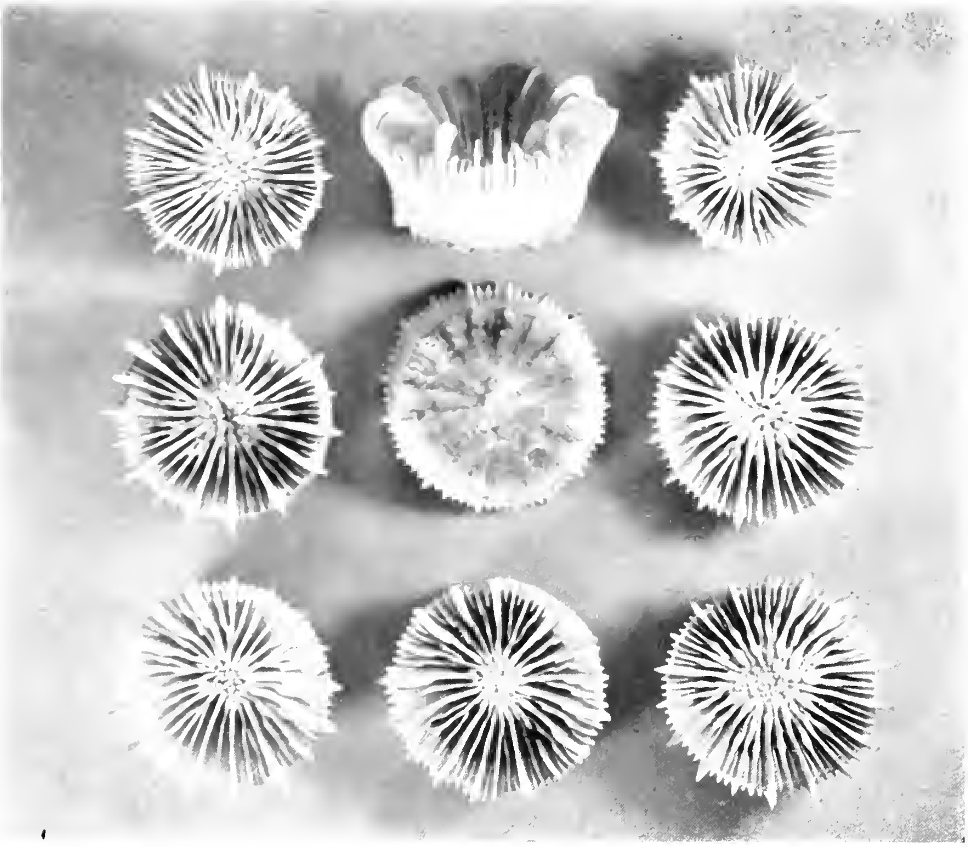

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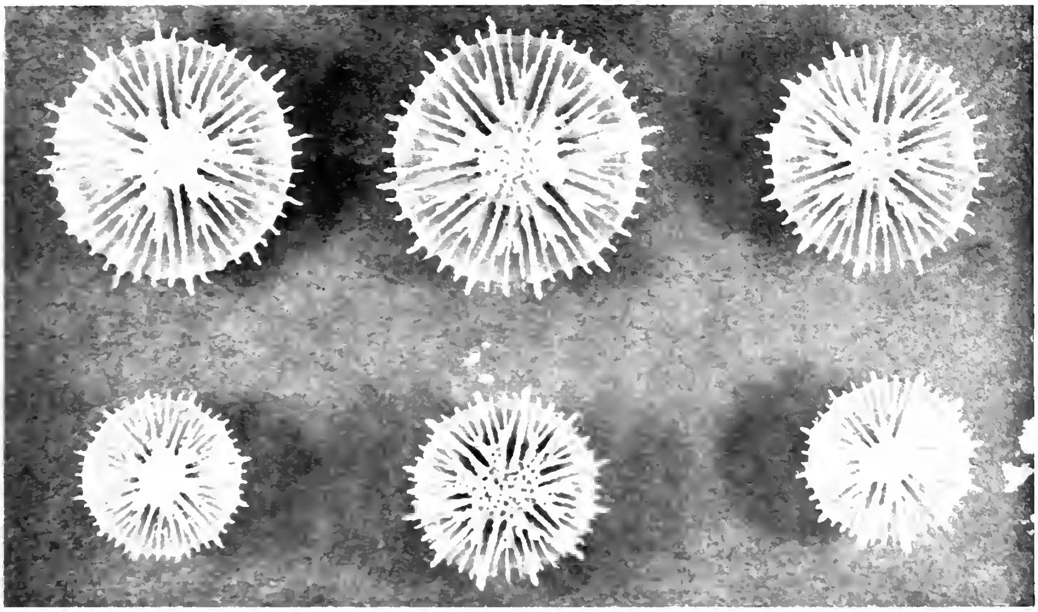
DESCRIPTION OF PLATE VII.

FIG. 16.—*Deltocyathus murrayi*, n. sp. × 1·8.

FIGS. 17 and 18.—*Fungiacyathus sarsi* n. sp. × 1. Five of these corals show on their underneath sides when magnified the sectors from which their discs were regenerating. The sixth was broken as shown here while still held together by polyp-tissues, in this resembling Sars' specimen.

FIGS. 19 and 20.—*Fungiacyathus nascornatus* n. sp. × 1·8.



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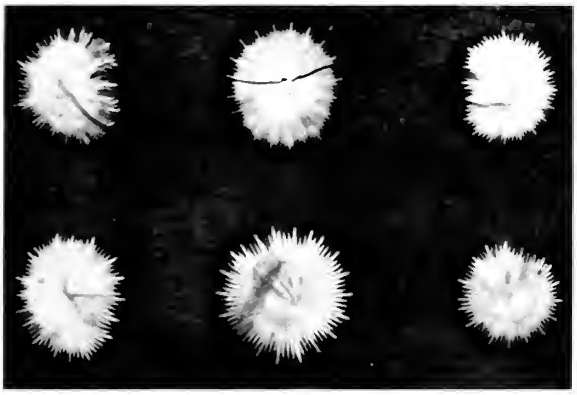

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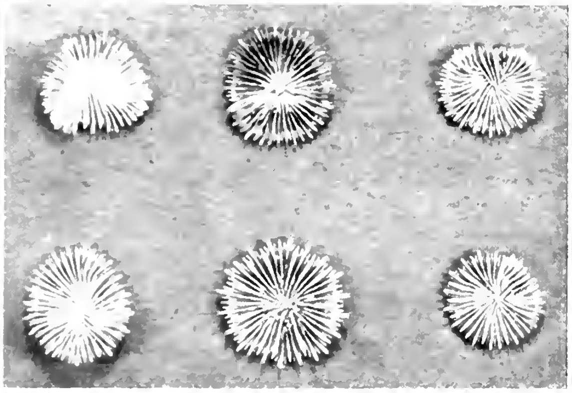

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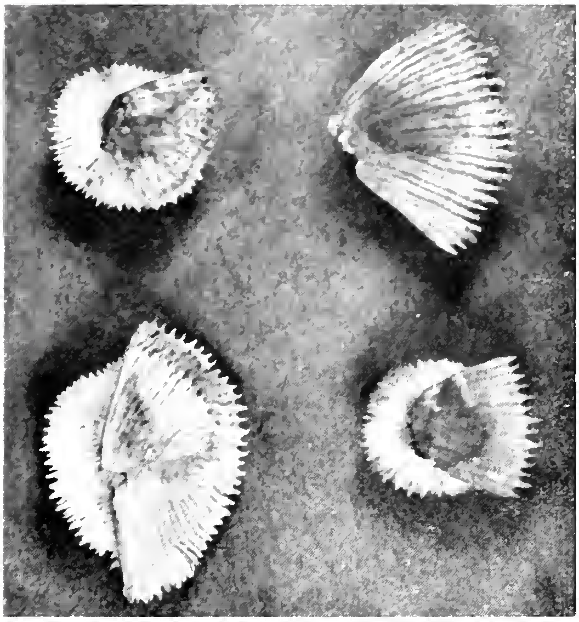

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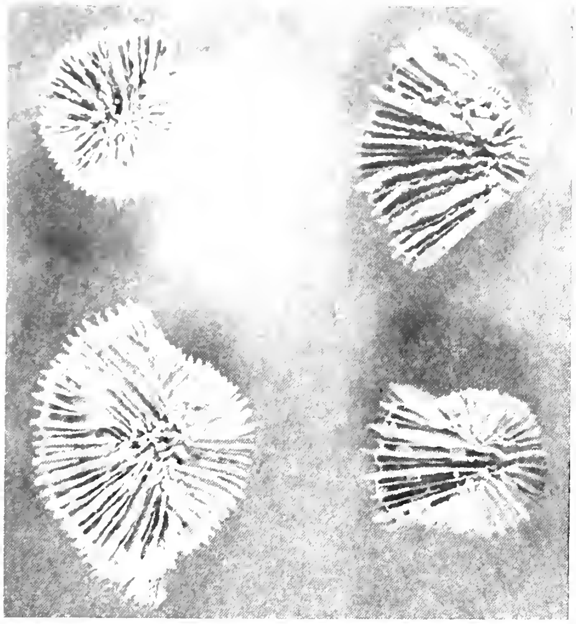

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BRITISH MUSEUM (NATURAL HISTORY)

THE
JOHN MURRAY EXPEDITION
1933–34

SCIENTIFIC REPORTS

VOLUME V, No. 8

THE EUPHAUSIACEA AND MYSIDACEA OF THE JOHN MURRAY EXPEDITION TO THE INDIAN OCEAN

BY
W. M. TATTERSALL, D.Sc.

WITH TWENTY-ONE TEXT-FIGURES

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AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
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Price Two Shillings and Sixpence

[*Issued 25th March, 1939*]

DESIGNED AND PRINTED BY

ADLARD & SON, LTD.
21, HART STREET, W.C.

AT BARTHOLOMEW PRESS DORKING

Made and printed in Great Britain

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WITH TWENTY-ONE TEXT-FIGURES.

I AM indebted to the courtesy of Lt.-Col. R. B. Seymour Sewell, C.I.E., F.R.S., for the opportunity of examining and reporting on the collections of Euphausiacea and Mysidacea collected by the John Murray Expedition to the Indian Ocean.

EUPHAUSIACEA.—Twenty-eight species are represented in the collection. None is new to science, and all have been recorded from some part of the Indian Ocean by earlier workers. The first Euphausian to be recorded from the Indian Ocean was *Thysanopoda obtusifrons* G. O. Sars by Alcock and Anderson (1894). In 1906 I recorded three species, *Euphausia mutica* Hansen, *Pseudeuphausia latifrons* (G. O. Sars) and *Nematoscelis microps* G. O. Sars, from stations in the Indian Ocean, and Hansen (1910) mentions *Euphausia mutica* Hansen and *Euphausia diomedeae* Ortm. from the same waters. The first comprehensive collection of Euphausiacea from the Indian Ocean was that made by Prof. Stanley Gardiner during the Sealark Expedition to the Seychelles and neighbouring seas, and reported on by me (1911 (2)). Twenty-two species were listed from that collection. Colosi (1917) recorded *Nematoscelis microps* G. O. Sars, *Stylocheiron armatum* Colosi and *Stylocheiron abbreviatum* G. O. Sars, and, in 1934 (1), Torelli gave a list of fifteen species, chiefly from the Red Sea and the Gulf of Aden. In the following table I have summarized all the earlier records of Euphausiacea from the Indian Ocean, and added for comparison the species collected by the Siboga Expedition (Hansen, 1910) and those in the present collection.

Table Showing the Species of Euphausiacea Known from the Indian Ocean and Neighbouring Waters.

	Tattersall, 1911(2), Seychelles.	Illig, 1930, Indian Ocean generally.	Torelli, 1934(1), Red Sea, etc.	Hansen, 1910, Siboga.	John Murray Expedition.	Other records.
Bentheuphausia amblyops	..	×	..	×	×	Anderson, 1897, Bay of Bengal.
Thysanopoda tricuspidata	×	×	..	×	×	..
T. monacantha	×	×	×	×	×	..
T. æqualis	×	×	..	×	×	..
T. pectinata	×	×	..	..	×	..
T. acutifrons	..	×	×	..	..	..
T. orientalis	..	×	×	×	×	..
T. microphthalma	×	×	..	..	..	Wood-Mason and Alcock, 1891, Bay of Bengal.
T. obtusifrons	..	×	..	..	×	Alcock and Anderson, 1894.
T. cornuta	..	×	..	..	×	..
Euphausia eximia	..	..	..	..	..	Torelli, 1934 (2).
E. diomedeae	..	×	×	×	×	Hansen, 1910; Torelli, 1934 (2).
E. messanensis	..	..	×	..	..	..
E. mutica	×	×	..	×	..	Tattersall, 1906; Hansen, 1910.
E. recurva	..	×	..	..	..	..
E. brevis	..	×	..	..	×	..
E. similis	×	×	..	×	×	..
E. tenera	×	×	..	×	×	..
E. hemigibba	×	..	..	×	..	..
E. pseudogibba	..	×	..	×	×	..
E. paragibba	×	×	..	×	×	..
E. distinguenda	..	×	×	..	×	..
E. sibogae	..	..	..	×	..	..
E. gibboides	..	×	..	..	×	..
E. sanzoi	..	..	×	..	..	..
Pseudeuphausia latifrons	×	×	×	×	×	Tattersall, 1906.
P. colosii	..	..	×	..	..	..
Thysanaessa inermis	..	×	..	..	..	..
Nematoscelis megalops	..	×	..	..	..	..
N. microps	×	×	..	×	×	Tattersall, 1906; Colosi, 1917.
N. gracilis	×	×	×	×	×	..
N. tenella	×	×	..	×	×	..
Nematobrachion boöpis	×	×	..	×	×	..
N. flexipes	×	×	..	×	×	..
Stylocheiron carinatum	×	×	..	×	×	..
S. armatum	..	..	×	..	..	Colosi, 1917.
S. affine	..	×	×	×	×	..
S. insulare	..	..	..	×	..	..
S. suhmii	×	×	×	..	..	..
S. microphthalma	×	×	..	×	..	..
S. longicorne	×	×	×	×	×	..
S. elongatum	×	×	..	..	×	..
S. maximum	..	×	..	×	×	..
S. abbreviatum	×	×	×	×	×	Colosi, 1917.

The total number of species in this table is forty-two, some of which are, however, of doubtful value. Of these the John Murray Expedition collected twenty-eight. The collection may, therefore, be regarded as a very representative one for the region surveyed. I have not attempted to deal further with the distribution of the individual species of Euphausians.

Mysidacea.—It is not possible to deal in the same way with the Mysidacean fauna of the Indian Ocean. The Euphausiacea are all pelagic and oceanic forms, but there are littoral and shallow-water as well as pelagic oceanic Mysids, and a summary of all the species known from the area surveyed by the John Murray Expedition would of necessity have to include both ecological types. It is felt that such a summary is beyond the scope of this report.

The collection includes twenty-seven species as compared with fourteen collected by the " Sealark ", twenty-seven by the " Valdivia " in the same waters, and forty-four by the " Siboga " in the waters of the East Indies. The comparison made with the " Siboga " Expedition is not, in reality, a strict one. The latter expedition, working among the islands of the East Indian Archipelago, collected vast numbers of shallow-water pelagic species, belonging mainly to the *Siriellinae* and *Gastrosaccinae*. The John Murray Expedition collected only oceanic forms, with one exception, *Lophogaster rotundatus* Illig, and the collection is deficient in species of *Siriella* and *Gastrosaccus* accordingly.

Three species are described as new to science, *Boreomysis verrucosa*, *Dactylamblyops murrayi* and *Thalassomysis sewelli*, a new genus of exceptional interest, which presents a number of unusual features. A further six species are recorded for the first time from the Indian Ocean, viz. *Gnathophausia gigas* W.-Suhm, *Gnathophausia elegans* G. O. Sars, *Eucopia major* Hansen, *Boreomysis microps* G. O. Sars, *Synerythrops intermedia* Hansen, and *Euchaetomera glyphidophthalma* Illig. The collection as a whole is typical of the Mysidacea of the oceanic bathypelagic fauna and a witness to the general world-wide distribution of the deep-water fauna.

A problem of some interest is presented by the geographical distribution of the species *Petalophthalmus oculatus* Illig. It is known only from deep water in the Indian Ocean and in the Caribbean Sea. It may be that this apparent discontinuous distribution is merely due to the lack of material from intermediate localities, and will disappear with further and more extended deep-sea biological investigation. Barnard, however, in his report on the Amphipoda of this Expedition, has made an interesting suggestion to account for the similar discontinuous distribution of two species of Amphipods common to the Atlantic and Indian Oceans. He asks whether it is too unreasonable to regard these deep-water forms as relics of the Cretaceo-Tertiary Sea of Tethys. It seems to me that this suggestion is worthy of further consideration. The pelagic fauna of the old Tethys Sea may be presumed to have been generally distributed throughout that area at one time, but with the evolution of new and more virile types to have become extinct or to have sought refuge in the deep-water pockets of that ocean and so, comparatively, to have escaped the more intensive competition of more populated areas. With the subsequent breaking up of the Tethys Sea these deep-water pockets have become isolated in the Atlantic and Pacific Indian Oceans of to-day with such of the fauna as has survived. *Petalophthalmus,* though undoubtedly specialized in many ways to its deep-water habitat, is, I think, a derivative from more primitive stock than the majority of present-day Mysids, and it is precisely such primitive forms which might be expected to survive under such conditions.

LIST OF SPECIES COLLECTED.

Euphausiacea.

Euphausiidae :
- *Bentheuphausia amblyops* (G. O. Sars).
- *Thysanopoda tricuspidata* H. M.-Edw.
- *T. monacantha* Ortm.
- *T. æqualis* Hansen.
- *T. pectinata* Ortm.
- *T. orientalis* Hansen.
- *T. obtusifrons* G. O. Sars.
- *T. cornuta* Illig.
- *Euphausia diomedeae* Ortm.
- *E. brevis* Hansen.
- *E. similis* G. O. Sars.
- *E. tenera* Hansen.
- *E. pseudogibba* Ortm.
- *E. paragibba* Hansen.

Euphausiidae (cont.) :
- *E. distinguenda* Hansen.
- *E. gibboides* Ortm.
- *Pseudeuphausia latifrons* (G. O. Sars).
- *Nematoscelis microps* G. O. Sars.
- *N. gracilis* Hansen.
- *N. tenella* G. O. Sars.
- *Nematobrachion boöpis* (Calman).
- *N. flexipes* (Ortm.).
- *Stylocheiron carinatum* G. O. Sars.
- *S. affine* Hansen.
- *S. longicorne* G. O. Sars.
- *S. elongatum* G. O. Sars.
- *S. maximum* Hansen.
- *S. abbreviatum* G. O. Sars.

Mysidacea.

Lophogastridae :
- *Lophogaster rotundatus* Illig.
- *Gnathophausia ingens* (Dohrn.).
- *G. gigas* W.-Suhm.
- *G. gracilis* W.-Suhm.
- *G. zoea* W.-Suhm var. *scapularis* Ortm.
- *G. elegans* G. O. Sars.

Eucopiidae :
- *Eucopia sculpticauda* Faxon.
- *E. unguiculata* W.-Suhm.
- *E. major* Hansen.

Petalophthalmidae :
- *Petalophthalmus armiger* W.-Suhm.
- *P. oculatus* Illig.

Mysidae :
- *Boreomysis microps* G. O. Sars.
- *B. spinifera* Coifmann.
- *B. verrucosa* n. sp.
- *Siriella thompsonii* H. M.-Edw.
- *S. gracilis* Dana.
- *Meterythrops indica* Hansen.
- *Dactylamblyops murrayi* n. sp.
- *Synerythrops intermedia* Hansen.
- *Thalassomysis sewelli* gen. et sp. nov.
- *Euchætomera typica* G. O. Sars.
- *E. tenuis* G. O. Sars.
- *E. oculata* Hansen.
- *E. glyphidophthalma* Illig.
- *Echinomysis chuni* Illig.
- *Gibberythrops acanthura* (Illig).
- *G. brevisquamosa* (Illig).

LIST OF STATIONS AT WHICH EUPHAUSIACEA AND MYSIDACEA WERE CAPTURED, WITH THE SPECIES OBTAINED AT EACH STATION.

Red Sea.

St. 5. 13.ix.33. N. 200. 500–0 m. 900 m.w.o. Oblique.

Euphausia diomedeae Ortm., *Euphausia gibboides* Ortm., *Stylocheiron abbreviatum* G. O. Sars.

Gulf of Aden.

St. 18. 21.ix.33. N. 200. 900–0 m. 1500 m.w.o. Oblique.

Thysanopoda orientalis Hansen, *Euphausia diomedeae* Ortm., *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Boreomysis spinifera* Coif.

St. 25. 10.x.33. Agassiz Trawl. 620 m.

Euphausia diomedeae Ortm., *Nematoscelis gracilis* Hansen, *Nematobrachion flexipes* (Ortm.), *Synerythrops intermedia* Hansen.

Northern Arabian Sea.

St. 61 A–B. 8.xi.33. Day. N.S. 50. Surface.

Pseudeuphausia latifrons (G. O. Sars).

St. 61 A–B. 8.xi.33. Day. N. 100. 500–0 m. 570 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Stylocheiron affine* Hansen.

St. 61 A–B. 8.xi.33. Day. N. 100. 1000–0 m. 1136 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Stylocheiron affine* Hansen.

St. 61 A–B. 8.xi.33. Day. N. 100. 1500–0 m. 1702 m.w.o.

Bentheuphausia amblyops (G. O. Sars), *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Gnathophausia gigas* W.-Suhm, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm., *Eucopia unguiculata* W.-Suhm.

St. 61 A–B. 8.xi.33. Day. N. 200. 2000–0 m. 2265 m.w.o.

Bentheuphausia amblyops (G. O. Sars), *Euphausia distinguenda* Hansen, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm.

St. 61 C–D. 8.xi.33. Night. N.S. 50. Surface.

Siriella thompsonii H. M.-Edw., *Siriella gracilis* Dana, *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Pseudeuphausia latifrons* (G. O. Sars).

St. 61 C–D. 9.xi.33. Night. N. 100. 500–0 m. 570 m.w.o.

Euphausia distinguenda Hansen, *Stylocheiron affine* Hansen.

St. 61 C–D. 9.xi.33. Night. N. 100. 1000–0 m. 1136 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Pseudeuphausia latifrons* (G. O. Sars), *Stylocheiron affine* Hansen, *Siriella gracilis* Dana.

St. 61 C–D. 9.xi.33. Night. N. 100. 1500–0 m. 1702 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm., *Eucopia major* Hansen, *Boreomysis spinifera* Coifmann, *Boreomysis verrucosa* n. sp., *Siriella gracilis* Dana, *Dactylamblyops murrayi* n. sp., *Thalassomysis sewelli* n. sp.

St. 61 C–D. 9.xi.33. Night. N. 200. 2000–0 m. 2265 m.w.o.

Bentheuphausia amblyops (G. O. Sars), *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Stylocheiron affine* Hansen, *Gnathophausia gracilis* W.-Suhm, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm.

Gulf of Oman.

St. 76. 29.xi.33. N. 100. 200–0 m. 300 m.w.o.

Euphausia distinguenda Hansen, *Stylocheiron affine* G. O. Sars, *Stylocheiron longicorne* G. O. Sars.

St. 76. 29.xi.33. N. 100. 600–0 m. 800 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematobrachion flexipes* (Ortm.), *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars.

St. 76. 29.xi.33. N. 100. 1500–0 m. 1800 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Nematobrachion flexipes* (Ortm.), *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars.

St. 76. 29.xi.33. N. 200. 2500–0 m. 2800 m.w.o.

Bentheuphausia amblyops (G. O. Sars), *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Gnathophausia gracilis* W.-Suhm, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm., *Boreomysis verrucosa* n. sp.

Northern Arabian Sea.

St. 85. 6.xii.33. Monegasque trawl. 1519–1705 m.

Gnathophausia gracilis W.-Suhm, *Gnathophausia zoea* W.-Suhm var. *scapularis* Ortm.

Central Arabian Sea.

St. 95. 18.xii.33. N. 200. 400–984 m. 1400 m.w.o.

Thysanopoda monacantha Ortm., *Euphausia diomedeae* Ortm., *Nematoscelis gracilis* Hansen, *Nematobrachion flexipes* (Ortm.), *Stylocheiron maximum* Hansen, *Eucopia unguiculata* W.-Suhm.

St. 96. 19.xii.33. N. 200. 400–645 m. 900 m.w.o.

Thysanopoda tricuspidata H. M.-Edw., *Thysanopoda monacantha* Ortm., *Thysanopoda aequalis* Hansen, *Thysanopoda pectinata* Ortm., *Thysanopoda orientalis* Hansen, *Thysanopoda* sp., *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia paragibba* Hansen, *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion boöpis* (Calman), *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron elongatum* G. O. Sars, *Stylocheiron maximum* Hansen, *Stylocheiron abbreviatum* G. O. Sars, *Eucopia unguiculata* W.-Suhm, *Boremomysis microps* G. O. Sars, *Siriella gracilis* Dana, *Meterythrops indica* Hansen, *Euchaetomera oculata* Hansen, *Gibberythrops acanthura* (Illig.).

St. 98. 22.xii.33. N. 200. 2800–0 m.

Euphausia diomedeae Ortm., *Euphausia similis* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Gnathophausia ingens* (Dohrn), *Eucopia unguiculata* W.-Suhm, *Eucopia sculpticauda* Faxon.

ZANZIBAR AREA.

St. 104. 11.i.34. Grab. 207 m.

Lophogaster rotundatus Illig.

St. 105. 11.i.34. Grab. 280 m.

Lophogaster rotundatus Illig.

St. 120. 20.i.34. Agassiz trawl. 2926 m.

Stylocheiron maximum Hansen, *Eucopia sculpticauda* Faxon.

St. 121. 21.i.34. Agassiz trawl.

Nematoscelis tenella G. O. Sars, *Gnathophausia ingens* (Dohrn).

SOUTHERN ARABIAN SEA (SEYCHELLES).

St. 131 A. 10.ii.34. N. 200. 600–0 m. Vertical.

Thysanopoda tricuspidata H. M.-Edw., *Thysanopoda aequalis* Hansen, *Thysanopoda obtusifrons* G. O. Sars, *Euphausia similis* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion boöpis* (Calman).

St. 131 D. 11.ii.34. N. 100. 500–0 m. Vertical.

Thysanopoda aequalis Hansen, *Thysanopoda orientalis* Hansen, *Thysanopoda* sp., *Euphausia brevis* Hansen, *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia similis* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematobrachion boöpis* (Calman), *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron elongatum* G. O. Sars, *Stylocheiron abbreviatum* G. O. Sars, *Euchaetomera tenuis*, G. O. Sars.

St. 131 D. 11.ii.34. N. 100. 1500–0 m. Vertical.

Thysanopoda aequalis Hansen, *Thysanopoda orientalis* Hansen, *Thysanopoda* sp., *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia similis* G. O. Sars, *Euphausia paragibba* Hansen, *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematobrachion boöpis* (Calman), *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron abbreviatum* G. O. Sars, *Eucopia unguiculata* W.-Suhm, *Petalophthalmus oculatus* Illig.

St. 131 D. 11.ii.34. N. 200. 2500–0 m. Vertical.

Thysanopoda tricuspidata H. M.-Edw., *Thysanopoda monacantha* Ortm., *Thysanopoda obtusifrons* G. O. Sars, *Thysanopoda pectinata* Ortm., *Euphausia diomedeae* Ortm., *Euphausia similis* G. O. Sars, *Euphausia paragibba* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion boöpis* (Calman), *Eucopia unguiculata* W.-Suhm.

Maldive Area.

St. 145 C. 1.iv.34. Day. N. 100. 300–0 m. Vertical.

Euphausia diomedeae Ortm., *Euphausia tenera* Hansen, *Euphausia pseudogibba* Ortm., *Nematoscelis gracilis* Hansen.

St. 145 C. 1.iv.34. Day. N. 100. 400–0 m. Vertical.

Euphausia distinguenda Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars.

St. 145 D. 2.iv.43. Night. N. 100. 50–0 m. Vertical.

Euphausia diomedeae Ortm., *Euphausia tenera* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars.

St. 145 D. 2.iv.34. Night. N. 100. 100–0 m. Vertical.

Thysanopoda pectinata Ortm., *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia pseudogibba* Ortm., *Nematoscelis gracilis* Hansen, *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron abbreviatum* G. O. Sars.

St. 145 D. 2.iv.34. Night. N. 100. 300–0 m. Vertical.

Thysanopoda monacantha Ortm., *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia pseudogibba* Ortm., *Nematoscelis gracilis* Hansen, *Stylocheiron carinatum* G. O. Sars, *Stylocheiron longicorne* G. O. Sars.

St. 145 D. 2.iv.34. Night. N. 100. 400–0 m. Vertical.

Euphausia diomedeae Ortm., *Euphausia tenera* Hansen, *Euphausia pseudogibba* Ortm., *Nematoscelis gracilis* Hansen, *Nematobrachion boöpis* (Calman), *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron abbreviatum* G. O. Sars.

Maldive Area.

St. 158. 7.iv.34. Agassiz trawl. 786–1170 m.

Gnathophausia elegans G. O. Sars.

St. 162. 10.iv.34. Agassiz trawl. 1829–2051 m.

Thysanopoda monacantha Ortm., *Eucopia unguiculata* W.-Suhm.

CENTRAL ARABIAN SEA.

St. 170. 27.iv.34. Agassiz trawl. 3676 m.

Thysanopoda orientalis Hansen, *Thysanopoda cornuta* Illig, *Gnathophausia ingens* (Dohrn), *Eucopia sculpticauda* Faxon.

St. 172. 29.iv.34. N. 100. 200–0 m. 510 m.w.o.

Euphausia diomedeae Ortm., *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron elongatum* G. O. Sars, *Stylocheiron maximum* Hansen, *Stylocheiron abbreviatum* G. O. Sars, *Euchaetomera typica* G. O. Sars.

St. 172. 29.iv.34. N. 100. 400–0 m. 820 m.w.o.

Thysanopoda monacantha Ortm., *Thysanopoda aequalis* Hansen, *Thysanopoda pectinata* Ortm., *Thysanopoda orientalis* Hansen, *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia paragibba* Hansen, *Euphausia distinguenda* Hansen, *Nematoscelis microps* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron elongatum* G. O. Sars, *Stylocheiron maximum* Hansen, *Stylocheiron abbreviatum* G. O. Sars, *Echinomysis chuni* Illig.

St. 172. 29.iv.34. N. 100. 850–0 m. 1500 m.w.o.

Thysanopoda monacantha Ortm., *Thysanopoda orientalis* Hansen, *Euphausia diomedeae* Ortm., *Euphausia tenera* Hansen, *Euphausia similis* G. O. Sars, *Euphausia paragibba* Hansen, *Euphausia distinguenda* Hansen, *Nematoscelis microps* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematocelis tenella* G. O. Sars, *Stylocheiron carinatum* G. O. Sars, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron elongatum* G. O. Sars, *Stylocheiron maximum* Hansen, *Stylocheiron abbreviatum* G. O. Sars, *Eucopia unguiculata* W.-Suhm, *Boreomysis microps* G. O. Sars.

St. 172. 29.iv.34. N. 200. 2091–0 m. 2665 m.w.o.

Bentheuphausia amblyops (G. O. Sars), *Thysanopoda monacantha* Ortm., *Thysanopoda orientalis* Hansen, *Euphausia diomedeae* Ortm., *Nematoscelis microps* G. O. Sars, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Stylocheiron maximum* Hansen, *Eucopia sculpticauda* Faxon, *Eucopia unguiculata* W.-Suhm, *Boreomysis microps* G. O. Sars, *Boreomysis verrucosa* n. sp.

GULF OF ADEN.

St. 184. 4.v.34. Agassiz trawl. 1270 m.

Petalophthalmus armiger W.-Suhm.

St. 185. 5.v.34. Agassiz trawl. 2000 m.

Nematoscelis gracilis Hansen.

St. 186. 5.v.34. N. 100. 250–0 m. 510 m.w.o.

Euphausia distinguenda Hansen, *Nematoscelis gracilis* Hansen, *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron maximum* Hansen.

St. 186. 5.v.34. N. 100. 575–0 m. 880 m.w.o.

Thysanopoda orientalis Hansen, *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Stylocheiron maximum* Hansen, *Euchaetomera glyphidophthalma* Illig, *Gibberythrops acanthura* (Illig).

St. 186. 5.v.34. N. 100. 600–0 m. 1150 m.w.o.

Thysanopoda orientalis Hansen, *Euphausia diomedeae* Ortm., *Euphausia distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Stylocheiron affine* Hansen, *Stylocheiron longicorne* G. O. Sars, *Gibberythrops acanthura* (Illig), *Gibberythrops brevisquamosa* (Illig).

St. 186. 5.v.34. N. 200. 952–0 m. 1500 m.w.o.

Thysanopoda monacantha Ortm., *Thysanopoda orientalis* Hansen, *Nematoscelis gracilis* Hansen, *Nematoscelis tenella* G. O. Sars, *Nematobrachion flexipes* (Ortm.), *Stylocheiron longicorne* G. O. Sars, *Stylocheiron maximum* Hansen.

EUPHAUSIACEA.

Family Euphausiidae.

Genus *Bentheuphausia* G. O. Sars.

Bentheuphausia amblyops (G. O. Sars).

Bentheuphausia amblyops, G. O. Sars, 1885; Anderson, 1897; Hansen, 1910 and 1912; Illig, 1930.
Euphausia simplex, W.-Suhm, 1875.

Occurrence :

St. 61 A–B. N. 100. 1500–0 m. 1702 m.w.o. One female, 28 mm.
St. 61 A–B. N. 200. 2000–0 m. 2265 m.w.o. One female, 28 mm.
St. 61 C–D. N. 200. 2000–0 m. 2265 m.w.o. Two females, 23–32 mm.
St. 76. N. 200. 2500 m. 2800 m.w.o. Three females, 17–30 mm.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. One female, 15 mm.

Genus *Thysanopoda* M.-Edw.

Thysanopoda tricuspidata M.-Edw.

Thysanopoda tricuspidata, G. O. Sars, 1885; Hansen, 1910, 1911 and 1912; Illig, 1930.

Occurrence :

St. 96. N. 200. 400–645 m. 900 m.w.o. One, immature, 11 mm.
St. 131 A. N. 200. 600 m. One, 19 mm.
St. 131 D. N. 200. 2500–0 m. One, 14 mm.

Thysanopoda monacantha Ortm.

Thysanopoda monacantha, Ortm., 1893; Hansen, 1910, 1911 and 1912; Illig, 1930.
Thysanopoda agassizi, Ortm., 1894.
Thysanopoda lateralis, Hansen, 1905 (1).
Thysanopoda ctenophora, Illig, 1908.

Occurrence:

St. 95. N. 200. 430–984 m. 1400 m.w.o. Two.
St. 96. N. 200. 400–645 m. 900 m.w.o. Ninety.
St. 131 D. N. 200. 2500 m. One.
St. 145 D. N. 100. 300–0. Three.
St. 162. Agassiz trawl. 1829–2051 m. Two.
St. 172. N. 100. 400–0 m. 820 m.w.o. Six.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Nine.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Thirty-six.
St. 186. N. 200. 952–0 m. 1500 m.w.o. Two.

Thysanopoda aequalis Hansen.

Thysanopoda aequalis, Hansen, 1905 (2), 1910, 1911 and 1912; Illig, 1930.
Thysanopoda obtusifrons, Lo Bianco, 1903.
Thysanopoda microphthalma, Lo Bianco, 1903.

Occurrence:

St. 96. N. 200. 400–645 m. 900 m.w.o. Four.
St. 131 A. N. 200. 600–0 m. One.
St. 131 D. N. 100. 500–0 m. Two.
St. 131 D. N. 100. 1500–0 m. Two.
St. 172. N. 100. 400–0 m. 820 m.w.o. One.

Thysanopoda obtusifrons G. O. Sars.

Thysanopoda obtusifrons, G. O. Sars, 1885; Hansen, 1910, 1911 and 1912; Illig, 1930.
Thysanopoda vulgaris, Hansen, 1905 (1).

Occurrence:

St. 131 A. N. 200. 600–0 m. One.
St. 131 D. N. 200. 2500–0 m. One.

Thysanopoda pectinata Ortm.

Thysanopoda pectinata, Ortm., 1893; Hansen, 1910, 1911 and 1912; Illig, 1930.
Parathysanopoda foliifera, Illig, 1909.

Occurrence:

St. 96. N. 200. 400–645 m. 900 m.w.o. Eleven.
St. 131 D. N. 200. 2500 m. One male, 33 mm.
St. 145 D. N. 100. 100–0 m. Two, immature.
St. 172. N. 100. 400–0 m. 820 m.w.o. One.

Remarks.—The two immature specimens from St. 145 both possess a lateral spine on the margin of the carapace. All the other specimens, which are adult, have no such spine.

Thysanopoda orientalis Hansen.

Thysanopoda orientalis, Hansen, 1910, 1911 and 1912; Illig, 1930.

Occurrence:

St. 18. N. 200. 900–0 m. 1500 m.w.o. Six.
St. 96. N. 200. 400–645 m. 900 m.w.o. Twenty-one.
St. 131 D. N. 100. 500–0 m. One, immature.
St. 131 D. N. 100. 1500–0 m. Two.
St. 170. Agassiz trawl. 3676 m. One adult male.
St. 172. N. 100. 400–0 m. 820 m.w.o. Twenty-five.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Nine.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Twelve.
St. 186. N. 100. 575–0 m. 880 m.w.o. Nineteen.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Seven.
St. 186. N. 200. 952–0 m. 1500 m.w.o. Thirty.

Remarks.—The young specimens of this species, like those of *T. pectinata,* possess a spine on the lower margin of the carapace.

Thysanopoda cornuta Illig.

Thysanopoda cornuta, Illig, 1905 (1) and 1930; Hansen, 1910, 1911 and 1912.
Thysanopoda insignis, Hansen, 1905 (1).

Occurrence:

St. 170. Agassiz trawl. 3676 m. One male, 58 mm.

Remarks.—This male specimen agrees with the figure given by Illig (1930) for a specimen which measured 79 mm. The antennular peduncles are somewhat stouter than in female specimens, and there is a dense tuft of fine setæ at the base of the outer flagellum. The condition is, in fact, quite similar to that described by Hansen for the male of *T. egregia.* The thickened antennular peduncles and the tuft of setæ are secondary sexual characters of the male and not specific characters. Illig has figured the copulatory organ of the first pleopod of the male, but omits p5, which is present as a small curved hooked process behind p4 in the view drawn by Illig.

Thysanopoda sp. juv.

Occurrence:

St. 131 D. N. 100. 500–0 m. Three.
St. 131 D. N. 100. 1500–0 m. One.

Remarks.—These specimens are too immature to determine with certainty. They probably belong to *T. monacantha* Ortm.

Thysanopoda sp. (*cornuta* group).

Occurrence:

St. 96. N. 200. 400–0 m. 900 m.w.o. One, 13 mm.
St. 131 D. N. 100. 1500–0 m. One, 9 mm.

Remarks.—Larval forms belonging to the *Thysanopoda cornuta* group of species have been described by Hansen (1912), Zimmer (1914), Tattersall (1926) and Illig (1930).

They agree in being of large size and of robust and clumsy form, but can be divided into two species, (A) those larvæ described by Hansen, Zimmer and all but one of those described by Illig, and (B) those described by Tattersall, one of those described by Illig and the specimens here recorded.

SPECIES A:

Hansen, 1912, p. 224, pl. 6, figs. 1 *a–e*.
Zimmer, 1914, p. 419, pl. xxvi, figs. 55–58.
Illig, 1930, p. 516, figs. 199–204.

This species is characterized by (1) ripple-like markings on the postero-lateral parts of the carapace; these are not mentioned by Hansen, but are conspicuous features of both Zimmer's and Illig's figures; (2) a broad rostral plate, with the antero-lateral angles rounded, produced in the mid-dorsal line into a very short acute spine hardly extending beyond the level of the antero-lateral corners, so that the anterior margin of the rostral plate is almost transverse; and (3) the presence of a long spiniform process from the dorso-lateral margin of the sixth abdominal somite.

SPECIES B:

Tattersall, 1926, p. 15, pl. 2, figs. 9–11.
Illig, 1930, p. 518, figs. 207–209.

This species is characterized by (1) the absence of ripple markings on the carapace; (2) a narrower rostral plate than in Species A, in which the lateral margins are somewhat convergent instead of being parallel, and the anterior margin is produced in the mid-dorsal line into a rather long rostral spine, which extends well beyond the antero-lateral corners; and (3) the absence of a spiny prolongation from the dorso-lateral margin of the sixth abdominal somite. The Murray specimens belong to Species B.

There are two known species of adult *Thysanopoda* which belong to the *cornuta* group, *T. cornuta* Illig and *T. egregia* Hansen. Hansen identifies his specimens of the larva belonging to species A as the young stages of *T. cornuta*, and Illig accepts this conclusion. If they are correct in their conclusions it is reasonable to assume that the larvæ of species B are those of *T. egregia*. Only a more complete series of specimens of each form can decide this point. Illig recorded a larva of species B from the Indian Ocean near to the Seychelle Islands.

Genus *Euphausia* Dana.

Euphausia brevis Hansen.

Euphausia brevis, Hansen, 1905 (2), 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE:

St. 131 D. N. 100. 500–0 m. One.

Euphausia diomedeae Ortm.

Euphausia diomedeae, Ortmann, 1894; Hansen, 1905 (2), 1910, 1911 and 1912; Torelli, 1934 (1) and (2).

Occurrence :

St. 5. N. 200. 500–0 m. 900 m.w.o. Four.
St. 18. N. 200. 900–0 m. 1500 m.w.o. One.
St. 25. Agassiz trawl. 620 m. Two.
St. 61 A–B. N. 100. 500–0 m. 570 m.w.o. Sixteen.
St. 61 A–B. N. 100. 1000–0 m. 1136 m.w.o. Twenty.
St. 61 A–B. N. 100. 1500–0 m. 1702 m.w.o. One hundred and forty-eight.
St. 61 A–B. N. 200. 2000–0 m. 2265 m.w.o. Nineteen.
St. 61 C–D. N.S. 50. Surface. Fifteen, immature.
St. 61 C–D. N. 100. 1000–0 m. 1136 m.w.o. Eighty-two.
St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. Thirty-three.
St. 61 C–D. N. 200. 2000–0 m. 2265 m.w.o. Eleven.
St. 76. N. 100. 600 m. 800 m.w.o. Fifty-one.
St. 76. N. 100. 1500 m. 1800 m.w.o. Forty-two.
St. 76. N. 200. 2500 m. 2800 m.w.o. Twelve.
St. 95. N. 200. 430–984 m. 1400 m.w.o. One hundred and two.
St. 96. N. 200. 400–645 m. 900 m.w.o. Fifty-three.
St. 98. N. 200. 2800–0 m. 2800 m.w.o. Four.
St. 131 D. N. 100. 500–0 m. Five.
St. 131 D. N. 100. 1500–0 m. Seven.
St. 131 D. N. 200. 2500–0 m. One.
St. 145 C. N. 100. 300–0 m. Fifteen.
St. 145 D. N. 100. 50–0 m. One.
St. 145 D. N. 100. 100–0 m. Five.
St. 145 D. N. 100. 300–0 m. Three.
St. 145 D. N. 100. 400–0 m. Three.
St. 172. N. 100. 200–0 m. 510 m.w.o. Twenty-eight.
St. 172. N. 100. 400–0 m. 820 m.w.o. One hundred and eighty-eight.
St. 172. N. 100. 850–0 m. 1500 m.w.o. One hundred and fifty-nine.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Four.
St. 186. N. 100. 575–0 m. 880 m.w.o. Two hundred and seventeen.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Forty-one.

Remarks.—This species and *E. distinguenda* are the two most characteristic species of *Euphausia* in the area explored by the John Murray Expedition. No very definite conclusions can be drawn from the above records as to the bathymetrical distribution of the species. They suggest that the region of greatest abundance lies between 500 and 1500 metres, and that in water of greater depth it is relatively scarce. At St. 61, where comparable day and night series of tow-nettings were taken, there is also an indication of migration towards the surface at night. At this station fifteen immature specimens were actually caught in the night surface tow-netting. On the other hand, Hansen records the species at a number of stations in the Eastern Pacific in some numbers at the surface, and, commenting on material in the Copenhagen Museum, says that most of it was taken at the surface. Unfortunately the time of day at which the gatherings were made is not given and it is impossible to say whether the species is normally found at or near the surface in the Eastern Pacific or migrates there with the approach of darkness.

Euphausia tenera Hansen.

Euphausia tenera, Hansen, 1905 (2), 1910, 1911 and 1912; Illig, 1930.
Euphausia gracilis, G. O. Sars, 1885.

OCCURRENCE:

St. 96. N. 200. 400–645 m. 900 m.w.o. Two.
St. 131 D. N. 100. 500–0 m. Thirty.
St. 131 D. N. 100. 1500–0 m. Twenty-seven.
St. 145 C. N. 100. 300–0 m. Seventeen.
St. 145 D. N. 100. 50–0 m. One.
St. 145 D. N. 100. 100–0 m. Eight.
St. 145. D. N. 100. 300–0 m. Three.
St. 145 D. N. 100. 400–0 m. Eight.
St. 172. N. 100. 400–0 m. 820 m.w.o. Fourteen.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Eight.

Euphausia similis G. O. Sars.

Euphausia similis, G. O. Sars, 1885; Hansen, 1911; Illig, 1930.

OCCURRENCE:

St. 98. N. 200. 2800–0 m. One male.
St. 131 A. N. 200. 600–0 m. One male and one female.
St. 131 D. N. 100. 500–0 m. One male and one immature.
St. 131 D. N. 100. 1500–0 m. One female.
St. 131 D. N. 200. 2500–0 m. One male and one female.
St. 172. N. 100. 850–0 m. 1500 m.w.o. One male.

REMARKS.—All these specimens appear to be the normal form, without abdominal spine and with a long, sharply-pointed rostrum.

Euphausia paragibba Hansen.

Euphausia paragibba, Hansen, 1910, 1911 and 1912; Tattersall, 1911 (2); Illig, 1930.

OCCURRENCE:

St. 96. N. 200. 400–645 m. 900 m.w.o. Two.
St. 131 D. N. 100. 1500–0 m. Nine.
St. 131 D. N. 200. 2500–0 m. One.
St. 172. N. 100. 400–0 m. 820 m.w.o. Fifteen.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Five.

Euphausia pseudogibba Ortmann.

Euphausia pseudogibba, Ortmann, 1893; Hansen, 1905 (1), 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE:

St. 145 C. N. 100. 300–0 m. One, parasitized by *Heterophryxus appendiculatus*.
St. 145 D. N. 100. 100–0 m. One.
St. 145 D. N. 100. 300–0 m. One.
St. 145 D. N. 100. 400–0 m. Four.

Euphausia gibboides Ortmann.

Euphausia gibboides, Ortmann, 1893; Hansen, 1905 (1), 1911 and 1912; Tattersall, 1925; Illig, 1930.

? *Euphausia sanzoi*, Torelli, 1934 (1).

OCCURRENCE:

St. 5. N. 200. 500–0 m. 900 m.w.o. Six females.

REMARKS.—These specimens must, I think, belong to the species named *E. sanzoi* by Torelli (1934 (1)) from specimens captured in the Red Sea, the locality of the present specimens. Unfortunately there are no males in the material, so that I cannot be sure on this point. At the same time I am of the opinion that the institution of *E. sanzoi* as a separate species is open to question. The differences between it and *E. gibboides* are almost all confined to the copulatory organs on the first pleopod of the male. In recording *E. gibboides* from off the coast of Natal (1925), I noted that the specimens differed from *E. gibboides* as described and figured by Hansen (1912) in having two protruding triangular acute tubercles on the median lobe of the male copulatory organs instead of one, and in having the tip of the terminal process bifid instead of simple. Torelli found these differences to hold for specimens from the Red Sea, and considered them of sufficient magnitude to warrant the formation of a new species, which she named *E. sanzoi*. Females can hardly be distinguished from those of *E. gibboides* and, in the absence of males, I refer the present specimens to *E. gibboides* rather than to *E. sanzoi*.

Euphausia distinguenda Hansen.

Euphausia distinguenda, Hansen, 1911 and 1912; Illig, 1930; Torelli, 1934 (1).

OCCURRENCE:

St. 61 A–B. N. 100. 500–0 m. 570 m.w.o. Thirty-eight.
St. 61 A–B. N. 100. 1000–0 m. 1136 m.w.o. Forty-six.
St. 61 A–B. N. 100. 1500–0 m. 1702 m.w.o. Four hundred and eighty-six.
St. 61 C–D. N.S. 50. Surface. One hundred and thirty-four.
St. 61 C–D. N. 100. 500–0 m. 570 m.w.o. Seven.
St. 61 C–D. N. 100. 1000–0 m. 1136 m.w.o. Three hundred and seventy-eight.
St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. Two hundred and eighty-two.
St. 61 C–D. N. 200. 2000–0 m. 2265 m.w.o. Two.
St. 76. N. 100. 200 m. 300 m.w.o. One hundred and six.
St. 76. N. 100. 600 m. 800 m.w.o. Three hundred and forty-seven.
St. 76. N. 100. 1500–0 m. 1800 m.w.o. One hundred and forty-eight.
St. 76. N. 200. 2500 m. 2800 m.w.o. One.
St. 96. N. 200. 400–645 m. 900 m.w.o. Two hundred and fifteen.
St. 131 D. N. 100. 1500–0 m. One.
St. 145 C. N. 100. 400–0 m. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. Thirty.
St. 172. N. 100. 400–0 m. 820 m.w.o. Eighty-nine.
St. 172. N. 100. 850–0 m. 1500 m.w.o. One hundred and one.
St. 186. N. 100. 250–0 m. 510 m.w.o. One.
St. 186. N. 100. 575–0 m. 880 m.w.o. Two hundred and twenty-nine.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Twenty-seven.

REMARKS.—This species is the most abundant species of *Euphausia* in the collection and one of the most characteristic species of the Indian Ocean. It would appear to have a bathymetrical distribution somewhat similar to that of *E. diomedeae*. The records at St. 61 are rather interesting, and suggest more clearly than was the case in *E. diomedeae* a vertical movement towards the surface during the hours of darkness. Over one hundred specimens were caught actually at the surface at night. The records at St. 61 are tabulated below :

	Day.	Night.
0 m.	8	134
500–0 m.	38	7
1000–0 m.	46	378
1500–0 m.	486	282
2000–0 m.	0	2

Hansen (1912) remarks that in the Eastern Pacific this species is often taken at the surface, but that the majority of the specimens so taken were immature or larval. There is, however, no time given at which the specimens were captured.

Genus *Pseudeuphausia* Hansen.

Pseudeuphasia latifrons (G. O. Sars).

Euphausia latifrons, G. O. Sars, 1885 ; Hansen, 1908.
Pseudeuphausia latifrons, Hansen, 1910, 1911 and 1912 ; Illig, 1930 ; Torelli, 1934 (1).

OCCURRENCE :

St. 61 A. N.S. 50. Surface. One.
St. 61 C. N.S. 50. Surface. One hundred and twenty.
St. 61 D. N. 100. 1000–0 m. 1136 m.w.o. Three.

REMARKS.—The striking difference between the day and night surface tow-nettings at St. 61 is interesting and suggests a migration towards the surface during hours of darkness. Unfortunately, however, there is no material of this species in the deeper hauls which would suggest at what level the species is most abundant during the daytime. It is probably entirely a species of the upper waters, and does not descend to any great depth during the day.

Genus *Nematoscelis* G. O. Sars.

Nematoscelis microps G. O. Sars.

Nematoscelis microps, G. O. Sars, 1885 ; Hansen, 1908, 1910, 1911 and 1912 ; Illig, 1930.
Nematoscelis rostrata, Ortmann, 1893.

OCCURRENCE :

St. 172. N. 100. 400–0 m. 820 m.w.o. Eight.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Three.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Two.

Nematoscelis gracilis Hansen.

Nematoscelis gracilis, Hansen, 1910, 1911 and 1912 ; Tattersall, 1911 (2) ; Illig, 1930 ; Torelli, 1934 (1).

Occurrence :

St. 18. N. 200. 900–0 m. 1500 m.w.o. One.
St. 25. Agassiz trawl. 620 m. One.
St. 76. N. 100. 600–0 m. 800 m.w.o. Two.
St. 95. N. 200. 430–984 m. 1400 m.w.o. Fourteen.
St. 96. N. 200. 400–645 m. 900 m.w.o. Three hundred and ninety-two.
St. 98. N. 200. 2800–0 m. Two.
St. 131 A. N. 200. 600–0 m. Seven.
St. 131 D. N. 100. 500–0 m. Four.
St. 131 D. N. 100. 1500–0 m. Thirteen.
St. 131 D. N. 200. 2500–0 m. Four.
St. 145 C. N. 100. 300–0 m. One.
St. 145 C. N. 100. 400–0 m. Seven.
St. 145 D. N. 100. 100–0 m. One.
St. 145 D. N. 100. 300–0 m. Three.
St. 145 D. N. 100. 400–0 m. Nine.
St. 172. N. 100. 200–0 m. 510 m.w.o. Nine.
St. 172. N. 100. 400–0 m. 820 m.w.o. Three hundred and fifty-nine.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Four hundred and twenty-eight.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Twenty-seven.
St. 185. Agassiz trawl. 2000 m. One.
St. 186. N. 100. 250–0 m. 510 m.w.o. One.
St. 186. N. 100. 575–0 m. 880 m.w.o. Thirty-seven.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Fifty-two.
St. 186. N. 200. 952–0 m. 1500 m.w.o. Five.

Remarks.—This species of *Nematoscelis* is very abundant in the Indian Ocean area and one of the characteristic species of the waters investigated. There is some evidence from the series of tow-nettings taken at St. 172 and St. 186 that the species is more abundant between 400 and 1000 metres than in the waters above and below that zone. On the other hand there is no suggestion that the species migrates towards the surface at night.

Nematoscelis tenella G. O. Sars.

Nematoscelis tenella, G. O. Sars, 1885 ; Hansen, 1905 (2), 1910, 1911 and 1912 ; Illig, 1930.
Nematoscelis mantis, Chun, 1896.
Nematoscelis sarsii, Chun, 1896.

Occurrence :

St. 18. N. 200. 900–0 m. 1500 m.w.o. One.
St. 96. N. 200. 400–645 m. 900 m.w.o. Eight.
St. 98. N. 200. 2800–0 m. One.
St. 121. Agassiz trawl. One.
St. 131 A. N. 200. 600–0 m. Six.
St. 131 D. N. 200. 2500–0 m. Four.
St. 145 C. N. 100. 400–0 m. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. Two.
St. 172. N. 100. 400–0 m. 820 m.w.o. Twenty-five.

St. 172. N. 100. 850–0 m. 1500 m.w.o. Nineteen.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Nine.
St. 186. N. 100. 575–0 m. 880 m.w.o. Eight.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Two.
St. 186. N. 200. 952–0 m. 1500 m.w.o. One.

Genus *Nematobrachion* Calman.

Nematobrachion boöpis (Calman).

Nematodactylus boöpis, Calman, 1896.
Nematobrachion boöpis, Calman, 1905 ; Hansen, 1905 (1) and (2), 1910, 1911 and 1912 ; Illig, 1930.

Occurrence :

St. 96. N. 200. 400–645 m. 900 m.w.o. Fourteen.
St. 131 A. N. 200. 600–0 m. One.
St. 131 D. N. 100. 500–0 m. One.
St. 131 D. N. 100. 1500–0 m. One.
St. 131 D. N. 200. 2500–0 m. Two.
St. 145 D. N. 100. 500–0 m. One.

Nematobrachion flexipes (Ortmann).

Stylocheiron flexipes, Ortmann, 1893.
Nematobrachion flexipes, Hansen, 1905 (2), 1910, 1911 and 1912 ; Illig, 1930.

Occurrence :

St. 18. N. 200. 900–0 m. 1500 m.w.o. One.
St. 25. Agassiz trawl. 620 m. Four.
St. 76. N. 100. 600 m. 800 m.w.o. Two.
St. 76. N. 100. 1500 m. 1800 m.w.o. Four.
St. 76. N. 200. 2500 m. 2800 m.w.o. Two.
St. 95. N. 200. 430–984 m. 1400 m.w.o. Eight.
St. 96. N. 200. 400–645 m. 900 m.w.o. Seven.
St. 98. N. 200. 2800–0 m. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. One.
St. 172. N. 100. 400–0 m. 820 m.w.o. Two.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. One.
St. 186. N. 100. 575–0 m. 880 m.w.o. Four.
St. 186. N. 100. 600–0 m. 1150 m.w.o. One.
St. 186. N. 200. 952–0 m. 1500 m.w.o. Two.

Remarks.—All these specimens have a well-developed spine on the lower margin of the carapace. The spine on the posterior dorsal median border of the third abdominal somite is sometimes excessively developed and may be more than half the length of the fourth abdominal somite.

Genus *Stylocheiron* G. O. Sars.

Stylocheiron carinatum G. O. Sars.

Stylocheiron carinatum, G. O. Sars, 1885 ; Hansen, 1910, 1911 and 1912 ; Illig, 1930.

OCCURRENCE :

St. 96. N. 200. 400–645 m. 900 m.w.o. Four.
St. 131 D. N. 100. 500–0 m. Six.
St. 131 D. N. 100. 1500–0 m. Three.
St. 145 D. N. 100. 50–0 m. Three.
St. 145 D. N. 100. 100–0 m. Four.
St. 145 D. N. 100. 300–0 m. Five.
St. 145 D. N. 100. 400–0 m. Nineteen.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Two.

REMARKS.—Female specimens from St. 131 were carrying eggs, indicating the early early spring as the breeding season in the Indian Ocean.

Stylocheiron affine Hansen.

Stylocheiron affine, Hansen, 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE :

St. 61 A–B. N. 100. 500–0 m. 570 m.w.o. One.
St. 61 A–B. N. 100. 1000–0 m. 1136 m.w.o. One.
St. 61 C–D. N. 100. 500–0 m. 570 m.w.o. Two.
St. 61 C–D. N. 100. 1000–0 m. 1136 m.w.o. Ten.
St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One.
St. 61 C–D. N. 200. 2000–0 m. 2265 m.w.o. One.
St. 76. N. 100. 200–0 m. 300 m.w.o. One.
St. 76. N. 100. 600–0 m. 800 m.w.o. Three.
St. 76. N. 100. 1500–0 m. 1800 m.w.o. Three.
St. 96. N. 200. 400–645 m. 900 m.w.o. Three.
St. 131 D. N. 100. 500–0 m. Seven.
St. 131 D. N. 100. 1500–0 m. One.
St. 145 D. N. 100. 100–0 m. One.
St. 145 D. N. 100. 500–0 m. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. Two.
St. 172. N. 100. 400–0 m. 820 m.w.o. Nineteen.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Eleven.
St. 186. N. 100. 250–0 m. 510 m.w.o. Three.
St. 186. N. 100. 575–0 m. 880 m.w.o. Three.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Six.

Stylocheiron longicorne G. O. Sars.

Stylocheiron longicorne, G. O. Sars, 1885; Hansen, 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE :

St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One.
St. 76. N. 100. 200 m. 300 m.w.o. Twelve.
St. 76. N. 100. 600 m. 800 m.w.o. Sixteen.
St. 76. N. 100. 1500 m. 1800 m.w.o. Five.
St. 96. N. 200. 400–645 m. 900 m.w.o. Six.
St. 131 D. N. 100. 500–0 m. One.
St. 131 D. N. 100. 1500–0 m. Two.

St. 145 D. N. 100. 100–0 m. One.
St. 145 D. N. 100. 300–0 m. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. Twenty-five.
St. 172. N. 100. 400–0 m. 820 m.w.o. Twenty.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Eleven.
St. 186. N. 100. 250–0 m. 510 m.w.o. Ten.
St. 186. N. 100. 575–0 m. 880 m.w.o. Nine.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Six.
St. 186. N. 200. 952–0 m. 1500 m.w.o. One.

Stylocheiron elongatum G. O. Sars.

Stylocheiron elongatum, G. O. Sars, 1885; Hansen, 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE:

St. 96. N. 200. 400–645 m. 900 m.w.o. One.
St. 131 D. N. 100. 500–0 m. One.
St. 172. N. 100. 200–0 m. 510 m.w.o. Three.
St. 172. N. 100. 400–0 m. 820 m.w.o. One.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Two.

Stylocheiron maximum Hansen.

Stylocheiron maximum, Hansen, 1910, 1911 and 1912; Illig, 1930.

OCCURRENCE:

St. 95. N. 200. 430–984 m. 1400 m.w.o. One.
St. 96. N. 200. 400–645 m. 900 m.w.o. Five.
St. 120. Agassiz trawl. 2926 m. One.
St. 172. N. 100. 200–0 m. 510 m.w.o. Four.
St. 172. N. 100. 400–0 m. 820 m.w.o. Seven.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Two.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. One.
St. 186. N. 100. 250–0 m. 510 m.w.o. One.
St. 186. N. 100. 575–0 m. 880 m.w.o. One.
St. 186. N. 200. 952–0 m. 1500 m.w.o. Three.

Stylocheiron abbreviatum G. O. Sars.

Stylocheiron abbreviatum, G. O. Sars, 1885; Hansen, 1905 (1), 1910, 1911 and 1912; Illig, 1930.
Stylocheiron chelifer, Chun, 1896.

OCCURRENCE:

St. 5. N. 200. 500–0 m. 900 m.w.o. Three.
St. 96. N. 200. 400–645 m. 900 m.w.o. Two.
St. 131 D. N. 100. 500–0 m. Two.
St. 131 D. N. 100. 1500–0 m. One.
St. 145 D. N. 100. 100–0 m. One.
St. 145 D. N. 100. 400–0 m. One.
St. 172. N. 100. 200–0 m. 510 m.w.o. One.
St. 172. N. 100. 400–0 m. 820 m.w.o. Three.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Three.

MYSIDACEA.

Sub-order LOPHOGASTRIDA.

Family Lophogastridae.

Genus *Lophogaster* M. Sars.

Lophogaster rotundatus Illig.

Lophogaster rotundatus, Illig, 1930.
Lophogaster typicus, var., Tattersall, 1911 (2).

Occurrence :

St. 104. Grab. 207 m. One, 21 mm.
St. 105. Grab. 280 m. Two, 21–22 mm.

Remarks.—Both specimens are somewhat damaged, but agree with Illig's description in the two fundamental characters of the species, namely, (1) the rounded postero-lateral corners of the carapace, and (2) the absence of coarse granules on the carapace. There is one point of difference from Illig's description. The median rostral spine is equal in length to the two lateral spines, and the whole rostral plate does not cover the antennular peduncles, but leaves the distal joint exposed. In Illig's drawing the central rostral spine is shown as longer than the lateral and extending to the distal end of the antennular peduncle. This character is, however, subject to considerable variation in other species of the genus (Ortmann, 1906). There are three teeth on the outer margin of the antennal scale in addition to the terminal tooth. The telson is damaged in all three specimens, but in a fragment of another specimen it is better preserved and shows only one spine on each side of the large apical spines, whereas Illig figures two in his specimen. The specimen which I recorded (1911 (2)) from the Saya de Malha Bank as *L. typicus* var. proves, on re-examination, to belong to this species. It has, however, five teeth on the outer margin of the antennal scale in addition to the terminal one.

Distribution.—Illig's material was taken in the Zanzibar Channel, in virtually the same locality as the present specimens. Apart from the earlier record from the Saya de Malha Bank no other specimens are known.

Genus *Gnathophausia* W.-Suhm.

Gnathophausia ingens (Dohrn).

Gnathophausia ingens, G. O. Sars, 1885 ; Ortmann, 1906 ; Hansen, 1912 ; Hansen, 1927 ; Illig, 1930.
Gnathophausia calcarata, G. O. Sars, 1885 ; Ortmann, 1906 ; Tattersall, 1911 (2).
Gnathophausia bengalensis, Wood-Mason and Alcock, 1891 (2).
Gnathophausia doryophora, Illig, 1930.
Gnathophausia goliath, A. Milne-Edwards. (Folin, 1887 ; Perrier, 1886 and 1891 ; Stebbing, 1893.)

Occurrence :

St. 98. N. 200. 2800–0 m. One, 27 mm.
St. 121. Agassiz trawl. Seven, 24–42 mm.
St. 170. Agassiz trawl. 3676 m. One, 40 mm.

Remarks.—The specimens were measured from the level of the eye to the end of the telson. They are all small, and serve to confirm Hansen's conclusion (1927) that *G. doryophora* was founded on a small specimen of *G. ingens*.

The elaborate synonymy of the species is the result of the work of Ortmann (1906) and Hansen (1912 and 1927). Ortmann united *G. bengalensis* with *G. calcarata* and suggested that both were young stages of *G. ingens*. Hansen confirmed these conclusions and later added *G. doryophora* Illig to the synonymy. Another name which has found its way into literature appears to refer to this species. Stebbing (1893, p. 29) mentions a species under the name of *Gnathophausia goliath* A. M.-Edw. The same species is referred to in the popular books of Folin (1887) and Perrier (1886 and 1891). I have been unable to trace the original paper in which the species was named, but, from a consideration of the works referred to, I believe the name was used for the gigantic specimen of *G. ingens*, measuring 210 mm., captured by the "Talisman" Expedition to the south of the Azores, and recorded by Hansen (1927) in his report on the Sergestidae and Schizopoda of that expedition.

Distribution.—Earlier records of this species from the Indian Ocean are given by Wood-Mason and Alcock (1891 (2)), Tattersall (1911 (2)), and Illig (1906 (2) and 1930). It is widely distributed in the tropical and sub-tropical oceans of the world.

Gnathophausia gigas W.-Suhm.

Gnathophausia gigas, W. Suhm, 1875; Sars, 1885; Ortmann, 1906; Hansen, 1927.
Gnathophausia drepanophora, Holt and Tattersall, 1905 (1); Illig, 1930.

Occurrence:

St. 61 B. N. 100. 1500–0 m. 1702 m.w.o. One, 26 mm.

Remarks.—The single specimen measured 26 mm. from the eye to the end of the telson. The rostral spine measured 7 mm., and was thus about one-quarter of the total length of the animal. The carapace from the tip of the rostral spine to the end of the posterior dorsal spine measured 16 mm., and the postero-lateral spine of the carapace measured 3 mm. in length and extended backwards as far as the posterior margin of the second abdominal somite. There were two teeth on the outer margin of the antennal scale in addition to the terminal one.

Distribution.—I can trace no earlier records of this species from the Indian Ocean. It has, however, a wide distribution in the oceans of the world, and appears to extend its range much more into the temperate zones, both in the north and south hemispheres, than does *G. ingens*. It is known from as far north as 57° lat. (Stephensen, 1933) and as far south as 48° lat. (Tattersall, 1913), both stations in the Atlantic, and from the Behring Sea in the Pacific (Ortmann, 1906).

Gnathophausia gracilis W.-Suhm.

Gnathophausia gracilis, W.-Suhm, 1875; G. O. Sars, 1885; Ortmann, 1906; Hansen, 1912; Illig, 1930.
Gnathophausia gracilis var. *brevispinis*, Wood-Mason and Alcock, 1891 (1).
Gnathophausia brevispinis, Wood-Mason and Alcock, 1891 (2); Anderson, 1897; Faxon, 1895.
Gnathophausia dentata, Faxon, 1893.
Gnathophausia bidentata, Illig, 1906 (2).
Gnathophausia sp., Chun, 1900, coloured plate opposite p. 500.

Occurrence:

St. 61 D. N. 200. 2000–0 m. 2265 m.w.o. Three, 30–70 mm., and four damaged young specimens.

St. 76. N. 200. 2500–0 m. 2800 m.w.o. Four, 22–78 mm.

St. 85. Monegasque trawl. 1519–1705 m. One, 40 mm.

REMARKS.—These specimens agree with Ortmann's description rather than with that of Sars, but, as Ortmann points out, the "Challenger" specimen was in a poor state of preservation. The pleural processes of the abdominal somites become relatively more expanded posteriorly in large specimens. The lower posterior spine of the carapace varies with age. It is well developed in the small specimen of 22 mm., but obsolete in the largest specimen. In a specimen of 40 mm. it is present on one side and absent on the other.

DISTRIBUTION.—Previously recorded from the Indian Ocean by Wood-Mason and Alcock (1891 (1) and (2)), and from the Arabian Sea by Anderson (1897). It is widely distributed in the deeper waters of the tropical oceans of the world.

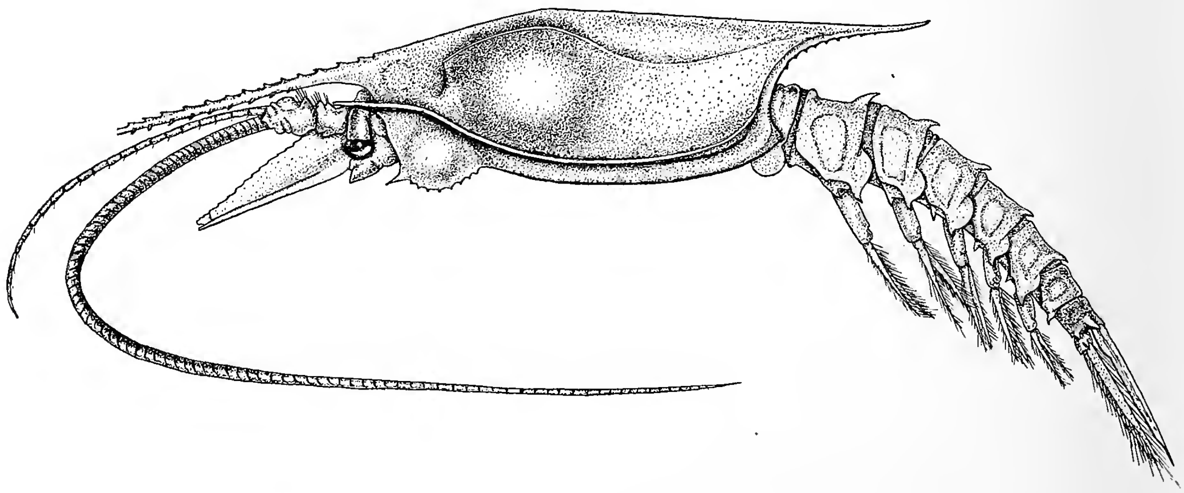
Gnathophausia zoea W.-Suhm, var. *scapularis* Ortmann. Text-figs. 1, 2.

Gnathophausia scapularis, Ortmann, 1906.

OCCURRENCE :

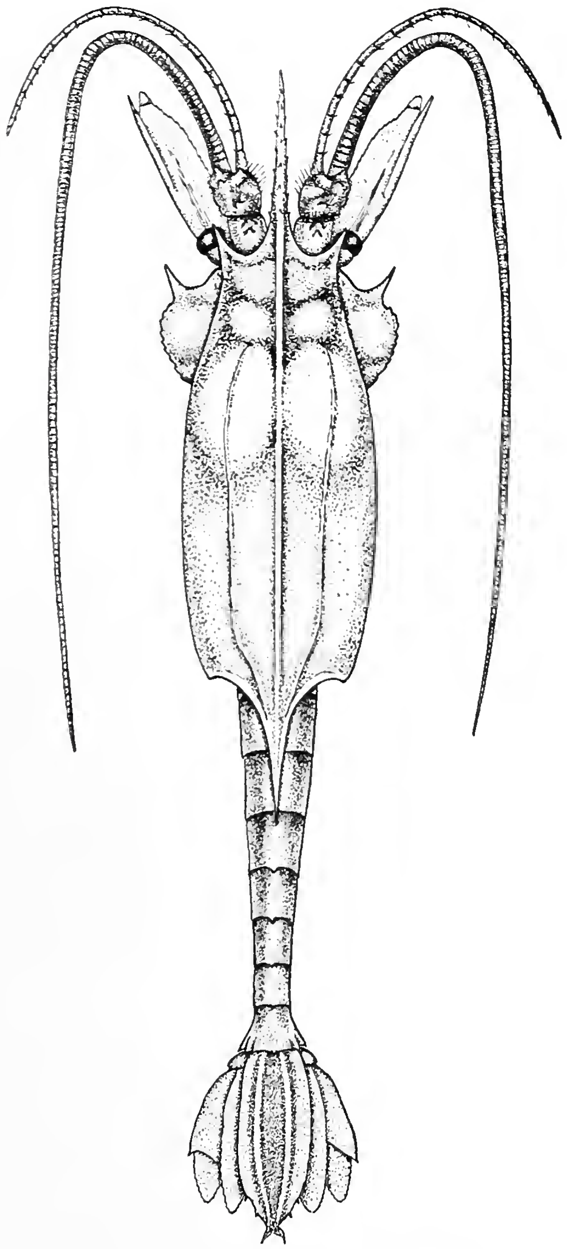
St. 61 A–B. N. 100. 1500–0 m. 1702 m.w.o. One, 33 mm.
St. 61 A–B. N. 200. 2000–0 m. 2265 m.w.o. One, 18 mm.
St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. Two, 12–25 mm.
St. 61 C–D. N. 200. 2000–0. m. 2265 m.w.o. Four, 22–60 mm.
St. 76. N. 200. 2500–0 m. 2800 m.w.o. One, 66 mm.
St. 85. Monegasque trawl. 1519–1705 m. One, 55 mm.

REMARKS.—Ortmann (1906) described a new species of *Gnathophausia*, *G. scapularis*, as "near *G. zoea*, but easily recognized by the anterior constriction of the carapace and the greatly expanded branchiostegal lobes". The specimens in this collection conform to



TEXT-FIG. 1.—*Gnathophausia zoea* W.-Suhm, var. *scapularis* Ortm. Lateral view. × 2.

that description. I have compared them with typical specimens of *G. zoea*, and find that the apparent constriction of the carapace towards the anterior end is due to an unusual inflation of the carapace on each side immediately behind the branchiostegal lobes, producing a prominent lateral bulge (Text-fig. 1). This has the effect, as seen in lateral view (compare Ortmann, 1906, fig. 3*a*), of causing the dorso-lateral keels to slope downwards as they run posteriorly, instead of being parallel to the median dorsal keel as shown by Sars (1885, pl. vi, fig. 6). It has the further effect, also noted by Ortmann (fig. 3*c*), of making the anterior part of the carapace between the dorso-lateral keels almost flat and horizontal, instead of sloping gradually down to the lateral portions of the carapace. The result is that the general appearance of the specimens is markedly different from that of typical specimens of *G. zoea*. In the details of their morphology and appendages,



TEXT-FIG. 2.—*Gnathophausia zoea* W.-Suhm, var. *scapularis* Ortm. Dorsal view. × 2.

however, the two forms are practically identical, as Ortmann himself pointed out. I do not think that the peculiar conformation of the carapace can be regarded as anything more than a varietal character, and it is in that light that I have viewed it here, reducing the species to varietal rank.

DISTRIBUTION.—*G. scapularis* was originally recorded from off Lower California in 460 fathoms. No other specimens have been noted. Great interest, therefore, attaches to the discovery of this variety in the deep water of the Indian Ocean.

Gnathophausia elegans G. O. Sars.

Gnathophausia elegans, G. O. Sars, 1885; Ortmann, 1906; Hansen, 1910.

OCCURRENCE:

St. 158. Agassiz trawl. 786–1170 m. One, 50 mm.

REMARKS.—This specimen agrees with Sars' description rather than with that of Ortmann in that the branchiostegal spine is rounded, and the abdominal somites do not appear to have depressed angular projections.

DISTRIBUTION.—This is one of the rarest species of the genus. It is known only from the Pacific Ocean, off Japan, South of Fiji and in the area explored by the Siboga Expedition. It has not been found previously in the Indian Ocean.

Family EUCOPIIDAE.

Genus *Eucopia* Dana.

Eucopia sculpticauda Faxon.

Eucopia sculpticauda, Faxon, 1895; Anderson, 1897; Hansen, 1910 and 1912; Tattersall, 1911 (2); Illig, 1930.
Eucopia intermedia, Hansen, 1905 (1).

OCCURRENCE:

St. 98. N. 200. 2800–0 m. Two, 21–28 mm.
St. 120. Agassiz trawl. 2926 m. One, 39 mm.
St. 170. Agassiz trawl. 3676 m. One, 28 mm.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Three, 26–38 mm.

DISTRIBUTION.—Previously recorded from the Bay of Bengal (Anderson, 1897) and the Indian Ocean, near to the Seychelles (Tattersall, 1911). It has a wide distribution in the deeper waters of the world, mainly in tropical and temperate regions, but has been recorded as far north as off the East coast of Greenland (Stephenson, 1933).

Eucopia unguiculata W.-Suhm.

Eucopia unguiculata, Hansen, 1910 and 1912; Tattersall, 1911 (2); Illig, 1930.
? *Eucopia australis*, Wood-Mason and Alcock, 1891 (2); Anderson, 1897.

OCCURRENCE:

St. 61 A–B. N. 100. 1500–0 m. 1702 m.w.o. One.
St. 95. N. 200. 430–984 m. 1400 m.w.o. Nine.
St. 96. N. 200. 400–645 m. 900 m.w.o. One.
St. 98. N. 200. 2800–0 m. Four.
St. 131 D. N. 100. 1500–0 m. One.
St. 131 D. N. 200. 2500–0 m. Two.
St. 162. Agassiz trawl. 1829–2051 m. One.
St. 172. N. 100. 850–0 m. 1500 m.w.o. One.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Twenty-two.

REMARKS.—Previous records from the area of the Murray Expedition are given by Tattersall (1911 (2)) and Illig (1930). I think the record of *E. australis* from the Arabian Sea (Anderson, 1897), and also those from the Bay of Bengal (Wood-Mason and Alcock, 1891 (2)) probably refer to this species or to *E. major*.

Eucopia major Hansen.

Eucopia major, Hansen, 1910 and 1912; Zimmer, 1914; Illig, 1930.

Occurrence:

St. 61 D. N. 100. 1500–0 m. 1702 m.w.o. Two.

Distribution.—This species has not previously been recorded from the Indian Ocean. It is known both from the Atlantic and Pacific Oceans, at moderately great depths.

Sub-order MYSIDA.

Family Petalophthalmidae.

Genus *Petalophthalmus* W.-Suhm.

Petalophthalmus armiger W.-Suhm.

Petalophthalmus armiger, W.-Suhm, 1875; G. O. Sars, 1885; Alcock and Anderson, 1894; Tattersall, 1925.

Occurrence:

St. 184. Agassiz trawl. 1270 m. One female, 30 mm., and one male, 28 mm.

Remarks.—Both specimens showed well-developed flagella, consisting of seven or eight joints, on the antennal peduncles. The specimens are not in very good condition, but agree, as far as I can see, very well with the specimen described by me in 1925.

Distribution.—The only previous record from the Indian Ocean is by Alcock and Anderson (1894), who recorded this species from the Laccadive Sea. It is a deep-water form widely distributed in the Atlantic and Pacific Oceans, but apparently very rare.

Petalophthalmus oculatus Illig. Text-fig. 3.

Petalophthalmus oculatus, Illig, 1906 (1) and 1930; Tattersall, 1937.

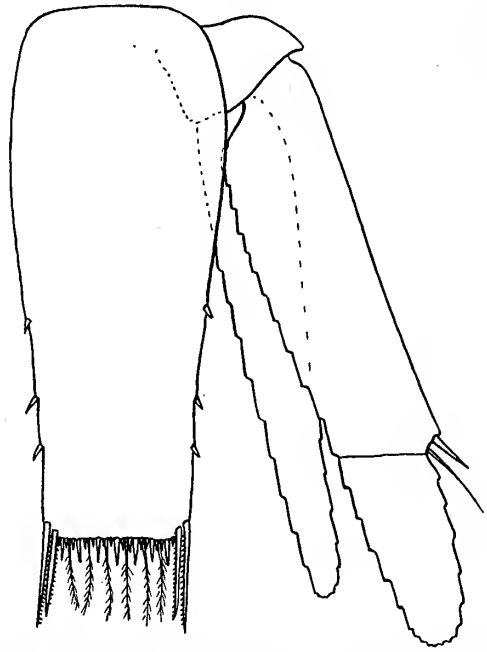
Occurrence:

St. 131 D. N. 100. 1500–0 m. One young specimen, 7 mm.

Remarks.—This remarkable and interesting species was described by Illig from specimens captured off Aden. His specimens measured 14–16 mm. in length, and, according to his figure of the female, were adult. The species differs from the type mainly in the possession of well-developed eyes, yellow-brown in colour, in which facets were observed in a well-developed cornea. The other most noticeable difference is to be found in the telson, which is relatively much shorter than in *P. armiger* and extends only to the distal end of the proximal joint of the outer uropod. Its apical armature is also distinctive, four long setæ being found among the spines arming the apex.

The specimen here recorded is a very small and apparently juvenile example, and it is not in very good condition. I have been led to refer it to this species mainly by the form of the telson and its armature. The eyes are not in good preservation, but show one point of difference from Illig's description in that they have a small finger-shaped process on the inner side.

The telson (Text-fig. 3) has the form and proportions shown by Illig. There are, however, only three spines on each lateral margin, whereas in Illig's specimens the number of lateral spines was seventeen. On the other hand the apex of the telson in the present specimen has more spines and setæ than Illig shows. Illig figures thirteen spines and four long delicate setæ, whereas in this specimen there are twenty-five spines, among which six long setæ are to be found. I think these differences may be explained as due to immaturity, the spines on the lateral margins increasing in number with age, while those at the apex suffer reduction. One other point of difference may be noted. The terminal joint of the mandibular palp is only about one-quarter of the length of the preceding joints, and has three long terminal setæ and three setæ on the lower margin, but none on the upper. In spite of the differences I believe the specimen to be referable to Illig's species. The points of agreement are many and striking.



TEXT-FIG. 3.—*Petalophthalmus oculatus* Illig. Telson and right uropods. × 50.

DISTRIBUTION.—The distribution of this species is rather remarkable. Illig's specimens were found in the Indian Ocean, near to Aden, and the present specimens rather further south, to the N.E. of the Seychelles. I have recently recorded it from very deep water in the Caribbean Sea (1937). It is not known from any other locality.

Family MYSIDAE.

Sub-family BOREOMYSINAE.

Genus *Boreomysis* G. O. Sars.

Boreomysis microps G. O. Sars. Text-fig. 4.

Boreomysis microps, G. O. Sars, 1885; Holt and Tattersall, 1905 and 1906; Tattersall, 1911 (1).
Boreomysis subpellucida, Hansen, 1905 (1)

OCCURRENCE:

St. 96. N. 200. 400–645 m. 900 m.w.o. One female, 10 mm.
St. 172. N. 100. 850–0 m. 1500 m.w.o. One female, 14 mm.
St. 172. N. 200. 2091–0 m. 2665 m.w.o. Two females, 14–17 mm.

Remarks.—This species can be recognized readily by the curious subchelate formation of the endopod of the second thoracic limb, to which I directed attention in 1911 (1). I give a figure of this limb from one of the Murray specimens (Text-fig. 4). It should be

Text-fig. 4.—*Boreomysis microps* G. O. Sars. Second thoracic limb. × 38.

compared with the corresponding limb in *B. verrucosa* (Text-fig. 8), where it is of more usual form.

Distribution.—This species has not been recorded previously from the Indian Ocean. It is widely distributed in the deep water of the tropical, sub-tropical and temperate regions of the Atlantic Ocean.

Boreomysis spinifera Coifmann.

Boreomysis spinifera, Coifmann, 1936.

OCCURRENCE:

St. 18. N. 200. 900–0 m. 1500 m.w.o. One adult male and one adult female, 13 mm.

St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One adult female, 14 mm.

REMARKS.—This species has recently been defined by Coifmann (1936) from specimens captured in the Gulf of Aden. It is remarkably close to *B. sibogae* Hansen, but differs, according to Coifmann, in the form and dimensions of the telson, the form of the ocular papilla, and by the presence of two spines on the inner margin of the inner uropod. No significance can be attached to the last of these differences. Hansen does not mention the spines on the uropod, but may simply have overlooked them. The most conspicuous difference is that of the telson. In Coifmann's figure each lobe of the apex of the telson is armed with one large spine, conspicuously larger than the spines on either side of it, whereas in Hansen's figure there is no such conspicuous spine, and the apical lobes appear, in consequence, more rounded than in Coifmann's figure. The present material agrees in this respect with Coifmann's figure, and I, therefore, refer it to her species. I am, however, doubtful whether such a small difference can be regarded as of specific value, in view of the otherwise close resemblance between the two forms. Both species differ from the other species of the genus in the relative great length of the proximal unarmed portion of the outer margin of the outer uropod, and can be readily recognized by this character and by the form of the rostral plate. It may well be that further material will show that the two species are synonymous.

Boreomysis verrucosa n. sp. Text-figs. 5–8.

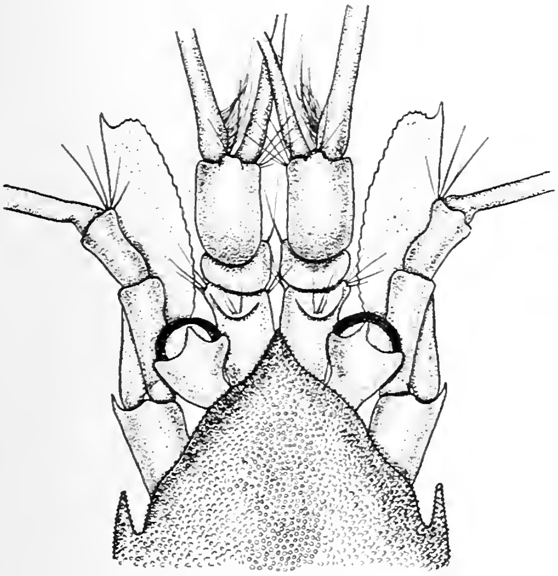
OCCURRENCE:

St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One female, 13 mm.

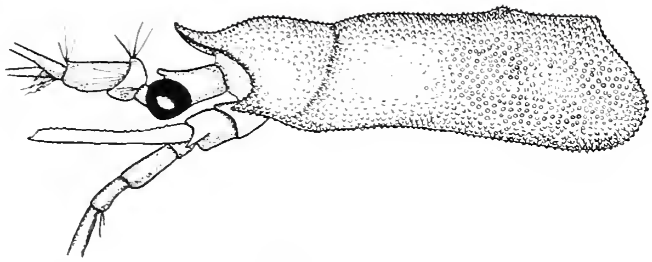
St. 76. N. 200. 2500 m. 2800 m.w.o. One adult male, 20 mm.

St. 172. N. 200. 2091–0 m. 2665 m.w.o. One female, 17 mm. Type.

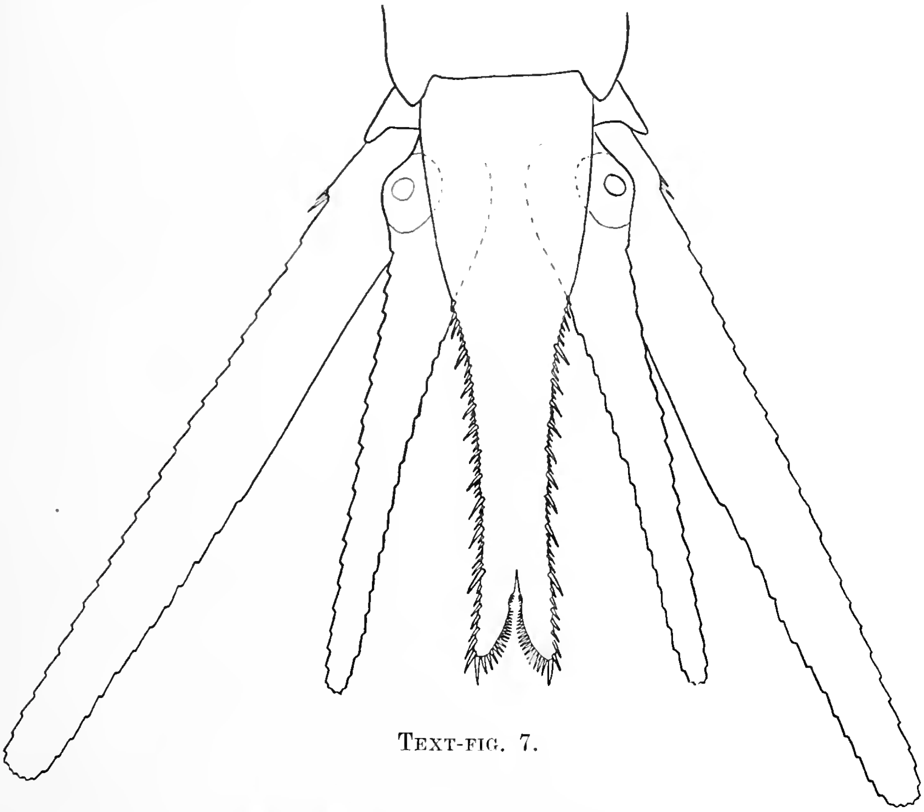
DESCRIPTION.—Whole of the thorax and abdomen covered by microscopic, evenly distributed tubercles, giving the integument the appearance of a very fine shagreen (Text-figs. 5, 6). Frontal plate (Text-fig. 5) considerably produced, extending forwards at least as far as the level of the eyes; margins feebly convex, the apex acuminate and somewhat upturned; front angle slightly less than a right angle; in side view (Text-fig. 6) the rostral plate is one-quarter of the length between its apex and the cervical groove. Eyes (Text-figs. 5, 6) somewhat small, about as broad as the stalk, light brown in colour; ocular tubercle prominent; in dorsal view (Text-fig. 5) only a narrow rim of the cornea visible, the major part of the cornea facing ventrally and outwardly. Antennal scale (Text-fig. 5) extending for one-quarter of its length beyond the antennular peduncle, four times as long as broad, broadest in the centre; inner margin more convex than the outer; terminal lobe not well developed, the outer marginal tooth extending beyond the apex of the scale. Exopod of the uropods (Text-fig. 7) with the unarmed proximal portion of its outer margin relatively short, about one-tenth of the total length, with two spines at the distal end. No spines on the inner margin of the inner uropods. Telson (Text-fig. 7) three and a quarter times as long as broad at the base, narrowing considerably in its distal half, where the narrowest part is less than half the breadth at the base; terminal cleft one-sixth of the total length, the proximal part of the cleft with a distinct dilation and a narrow slit at the bottom; lateral margins armed for about the distal two-thirds of their length with a large number of spines arranged in groups. There are about ten spines of larger size, between which are smaller spines in groups of three to seven.



TEXT-FIG. 5.



TEXT-FIG. 6.

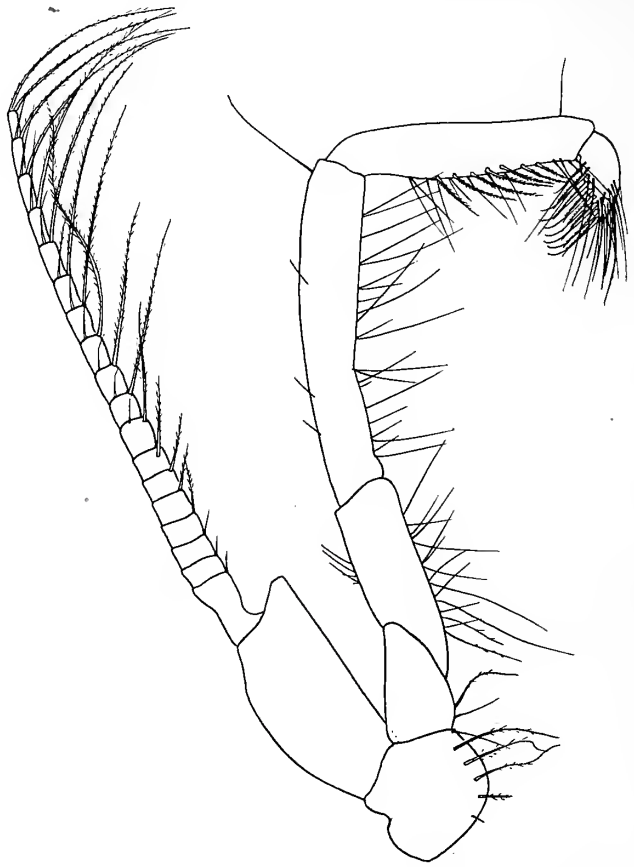


TEXT-FIG. 7.

TEXT-FIG. 5.—*Boreomysis verrucosa* n. sp. Dorsal view of anterior end. × 16.
TEXT-FIG. 6.—*Boreomysis verrucosa* n. sp. Lateral view of carapace. × 10.
TEXT-FIG. 7.—*Boreomysis verrucosa* n. sp. Telson and uropods. × 38.

I figure the second thoracic limb (Text-fig. 8) for comparison with that of *B. microps* (Text-fig. 4). It will be seen that in this new species there is practically no trace of a palmar margin bounded by a tooth, such as is characteristic of *B. microps*.

Length of an adult male, 20 mm., of an adult female, 17 mm.



TEXT-FIG. 8.—*Boreomysis verrucosa* n. sp. Second thoracic limb. × 29.

REMARKS.—This species is at once distinguished from all other described species by the character of the integument. I can find no other species in which the integument has been described as other than perfectly smooth. Otherwise the species is a typical bathypelagic member of the genus, closely allied to *B. microps*. It belongs to the small-eyed group of species, and the telson has the peculiar dilation in the apical cleft which is characteristic of *B. microps* G. O. Sars, *B. rostrata* Illig, *B. inermis* Hansen and other forms. The rostral plate recalls rather strongly that described in *B. rostrata* by Illig (1930).

Sub-family SIRIELLINAE.

Genus *Siriella* Dana.

Siriella thompsonii H. M.-Edw.

Siriella thompsonii, Hansen, 1910 (with full synonymy).

OCCURRENCE :

St. 61 C–D. N.S. 50. Surface. Six.
St. 145 D. N. 100. 50–0 m. One.

Siriella gracilis Dana.

Siriella gracilis, Hansen, 1910.

OCCURRENCE :

St. 61 C–D. N.S. 50. Surface. Several hundreds.
St. 61 C–D. N. 100. 1000–0 m. 1136 m.w.o. Three.
St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One.
St. 96. N. 200. 400–645 m. 900 m.w.o. One.

REMARKS.—The occurrence of hundreds of this species at the surface at night is noteworthy. The species is an upper water form and its occurrence in the deep water tow-nettings must be regarded as accidental.

Sub-family MYSINAE.

Tribe ERYTHROPINI.

Genus *Meterythrops* S. I. Smith.

Meterythrops indica Hansen.

Meterythrops indica, Hansen, 1910; Illig, 1930.
Meterythrops affinis, Coifmann, 1936 (1) and 1936 (2).

OCCURRENCE :

St. 96. N. 200. 400–645 m. 900 m.w.o. One, 6 mm.

REMARKS.—The specimen is immature, but appears to agree very well with Hansen's description and figures. There is one tooth on the outer margin of the antennal scale in addition to the terminal one. The apex of the telson bears two pairs of spines and a pair of plumose setæ. The inner pair of spines is about one-quarter as long as the telson and somewhat longer than the plumose setæ. The apical armature in Hansen's specimen was broken away.

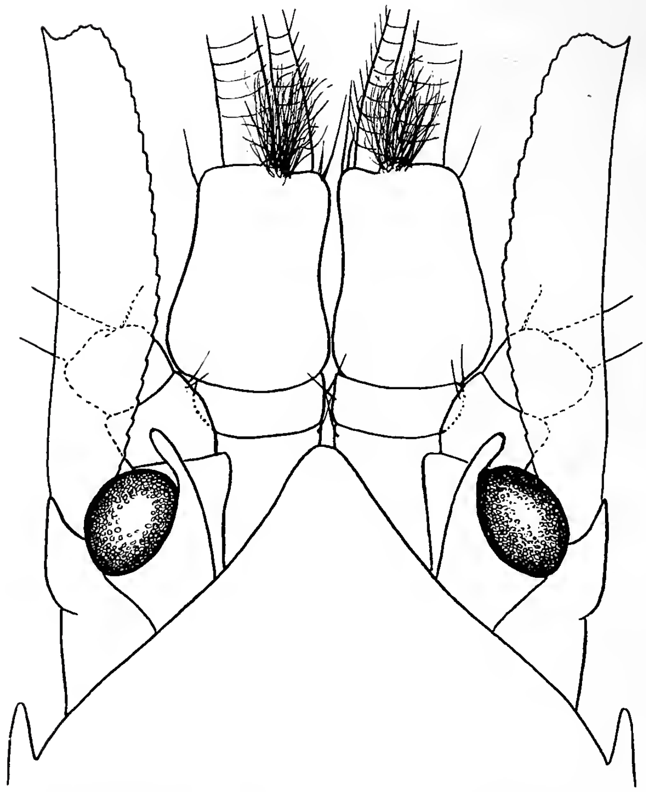
I can see no valid grounds for separating *M. indica* and *M. affinis*. The latter has two or three teeth on the antennal scale, and the outer pair of spines on the telson is rather longer than in my specimen, but in all essential characters the two species are identical. Coifmann institutes an elaborate comparison between *M. affinis* and *M. picta*, but makes no reference to the relation which her species may have to *M. indica*. The latter is, in reality, very closely allied to *M. picta*, and the differences between the two species are very slight. Even the colouring of the two forms is similar and characteristic, the prominent reddish-brown coloration of the gastric region being a feature of *M. picta* as well as *M. indica*.

DISTRIBUTION.—Hansen records this species from the waters of the Dutch East Indies. Illig noted its capture in the Indian Ocean to the East of Ceylon, and also from two stations in the Gulf of Aden. Illig also records a small specimen from the Atlantic Ocean, S.W. of Cape Bojador. Coifmann's material of *M. affinis* was from the Gulf of Aden.

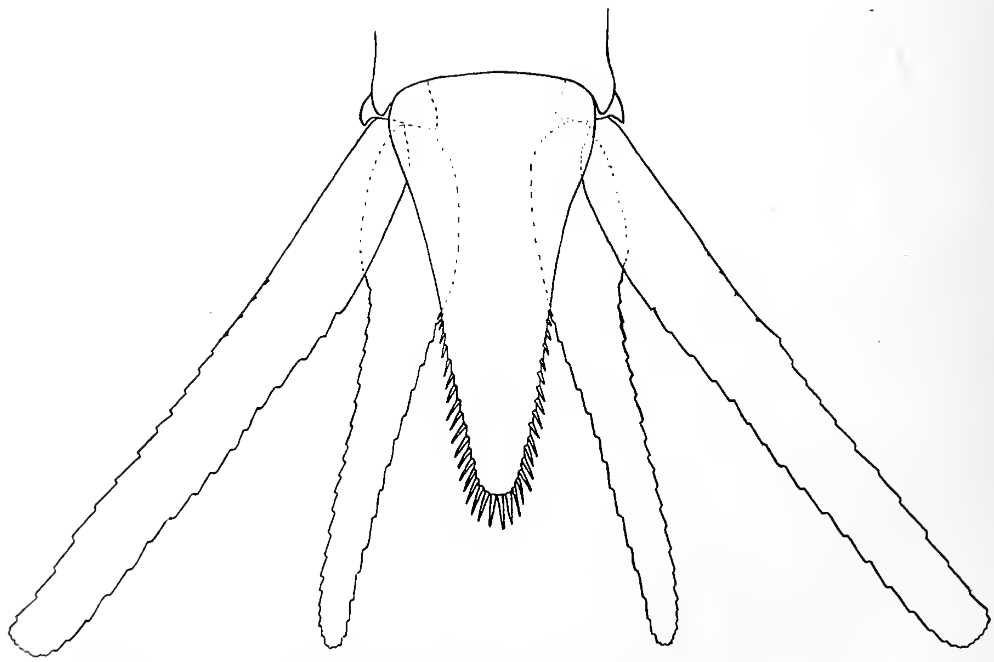
Dactylamblyops murrayi n. sp. Text-figs. 9, 10.

OCCURRENCE :

St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. One female, 12 mm., and one juv., 5 mm.



TEXT-FIG. 9.—*Dactylamblyops murrayi* n. sp. Dorsal view of anterior end. × 40.



TEXT-FIG. 10.—*Dactylambyops murrayi* n. sp. Telson and uropods. × 60.

Description.—Small, somewhat slender in form. Frontal plate (Text-fig. 9) somewhat produced, extending forwards slightly beyond the eyes and almost to the distal end of the basal joint of the antennular peduncle, slightly less than twice as broad as long, apex bluntly rounded. Eyes (Text-fig. 9) small, pale golden brown in colour; ocular process long, projecting well beyond the cornea, and free of the eyestalk for the greater part of its length. Antennal scale (Text-fig. 9) rather longer and narrower than in most species of the genus, extending for nearly one-third of its length beyond the antennular peduncle, five times as long as broad; outer margin terminating in a spine, which is about on the same level as the apex of the scale. Outer uropod twice as long as the telson. Inner uropod one and a half times as long as the telson, with a single spine on the inner margin in the region of the statocyst. Telson (Text-fig. 10) rather elongate triangular in shape, twice as long as broad at its base, lateral margins feebly concave, with the distal half armed by about 28 rather closely-set spines, increasing gradually but only very slightly in size towards the apex; no terminal plumose setæ. Length of a not quite adult female, 12 mm.

It should be explained that the figure of the telson and uropods (Text-fig. 10) was made from the small specimen. The outer uropods are considerably shorter than in the larger specimen, and the telson has only 18 spines on each lateral margin.

The figures, however, serve to show the general form and armature of those appendages in the species and the differences are merely those due to age.

Remarks.—This species is most closely allied to *D. fervida* Hansen, and *D. latisquamosa* Illig, but differs from both of them in the longer and narrower antennal scale and in the longer ocular process. In both these species the antennal scale is somewhat shorter than the antennular peduncle and only about twice as long as broad, while the ocular process in both is quite short, with only its terminal surface free. *D. murrayi* has the rostral plate of essentially the same form as in *D. fervida*. In *D. latisquamosa* the rostral plate has an acute apex, and is somewhat longer and narrower than in the other two species.

Genus *Synerythrops* Hansen.

Synerythrops intermedia Hansen. Text-figs. 11–13.

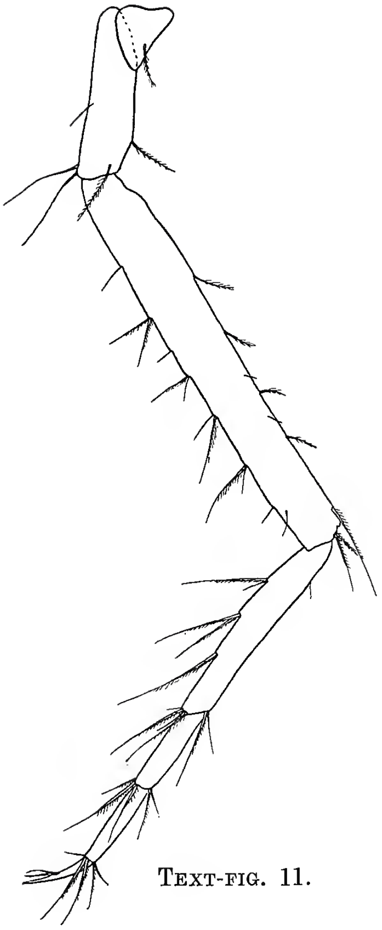
Synerythrops intermedia, Hansen, 1910.

Occurrence :

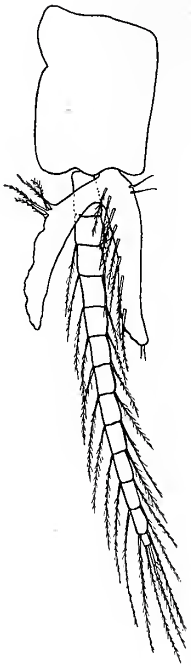
St. 25. Agassiz trawl. 620 m. One male, 13 mm.

Remarks.—The occurrence of an adult male allows of the description of the pleopods of the male in this genus. They have essentially the general structure of those in males of the genus *Erythrops* and its allies, but are interesting by reason of the fact that the pseudobranchial processes of the endopods are in the form of a long narrow lobe (Text-figs. 12, 13), instead of the much shorter plate-like appendage. In the first pleopod this process is as long as the endopod itself. Otherwise there are no modifications on any of the pleopods. I figure the distal joints of the endopod of the third thoracic limb to show the form of these appendages (Text-fig. 11). The eye has a small ocular papilla on the inside of the cornea. There are two spines on the inner margin of the inner uropod.

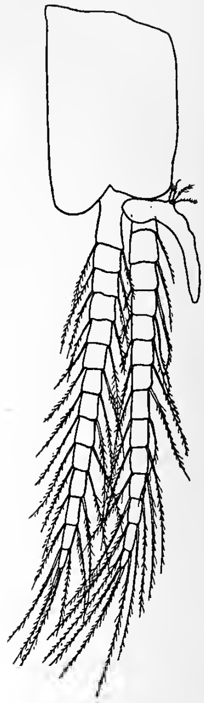
Distribution.—This species is known from the waters of the East Indies (Hansen, 1910), and doubtfully from the Great Barrier Reef. It has not previously been recorded from the Indian Ocean.



TEXT-FIG. 11.



TEXT-FIG. 12.



TEXT-FIG. 13.

TEXT-FIGS. 11–13.—*Synerythrops intermedia* Hansen. FIG. 11.—Endopod of third thoracic limb. × 29. FIG. 12.—First pleopod of the male. × 29. FIG. 13.—Second pleopod of the male. × 29.

Thalassomysis gen. nov.

DIAGNOSIS.—Integument thin and membranous. Carapace without rostral plate, front margin evenly arcuate and slightly upturned. Antennal scale setose all round, without a terminal spine on the outer margin. Labrum very aberrant and asymmetrical; left half of the posterior margin of more or less normal form, right half produced into a strongly chitinized blunt recurved and rather hook-like process, covered with microscopic tubercles, which appears to work against the right mandible and possibly acts as an additional grinding or triturating organ. Left mandible with the incisive part and the movable process well developed; four setæ between the movable process and the molar process, which is somewhat truncate. Right mandible with a row of five spines between the incisive part and the rather sharply pointed molar process. Second joint of the mandibular palps narrower than is usual. Maxillules with six cylindrical or sausage-shaped processes on the endopodite in addition to more normal setæ. Remaining mouth-parts and thoracic appendages not presenting any special characters of generic value. First thoracic limb with both exopodite and epipodite. Second thoracic limb with well-developed exopodite. Telson extremely long and narrowly pointed, longer than the inner uropod; apex entire without terminal incision, lateral margins armed with numerous spines on the distal portions; no plumose setæ at the apex.

Type : *Thalassomysis sewelli* sp. nov.

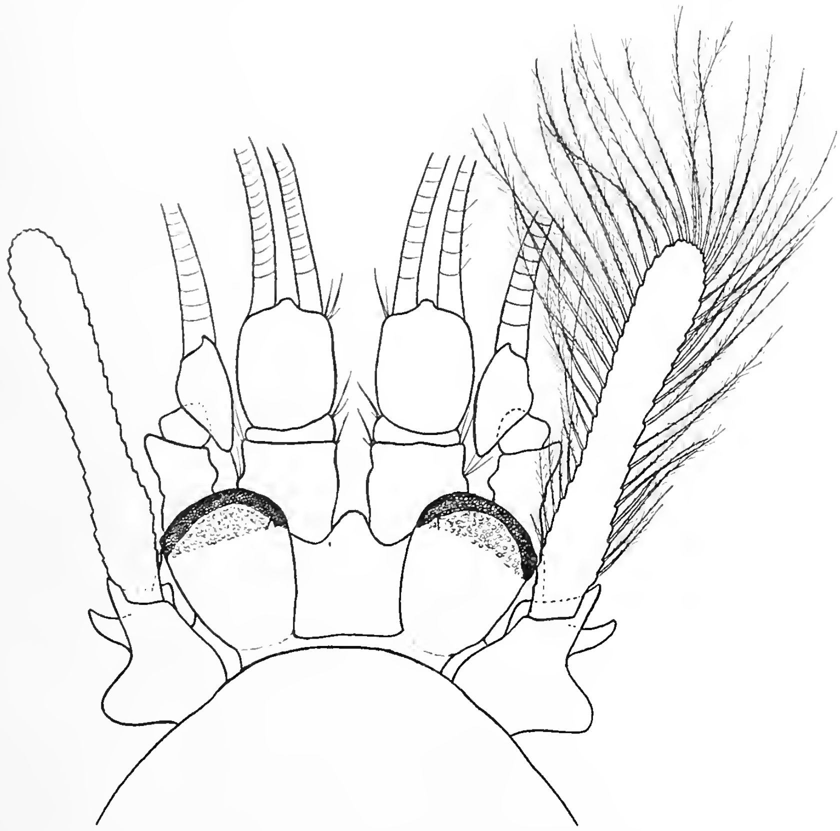
Remarks.—This new genus is distinguished at once by the characters of the antennal scale and the telson. The labrum and maxillules present features unknown elsewhere in the group. In the absence of male specimens it is impossible to say to what tribe this genus should be referred. In its general form and in the form and structure of the majority of its appendages it shows the closest resemblance to the members of the Erythropini, and I regard it as a somewhat aberrant, oceanic and bathypelagic member of that group. The antennal scale without outer terminal spine and with setæ all round its margins recalls in a general way that of the Leptomysini, but there is no distal joint and the setæ are long and slender, and less stiff than those in this tribe. A somewhat similar scale is found in *Echinomysis*, but in this genus the proximal part of the outer margin is devoid of setæ, though without terminal spine. In fact *Thalassomysis* is closely allied to *Echinomysis* and the group of deep-water genera to which it belongs.

Thalassomysis sewelli sp. nov. Text-figs. 14–21.

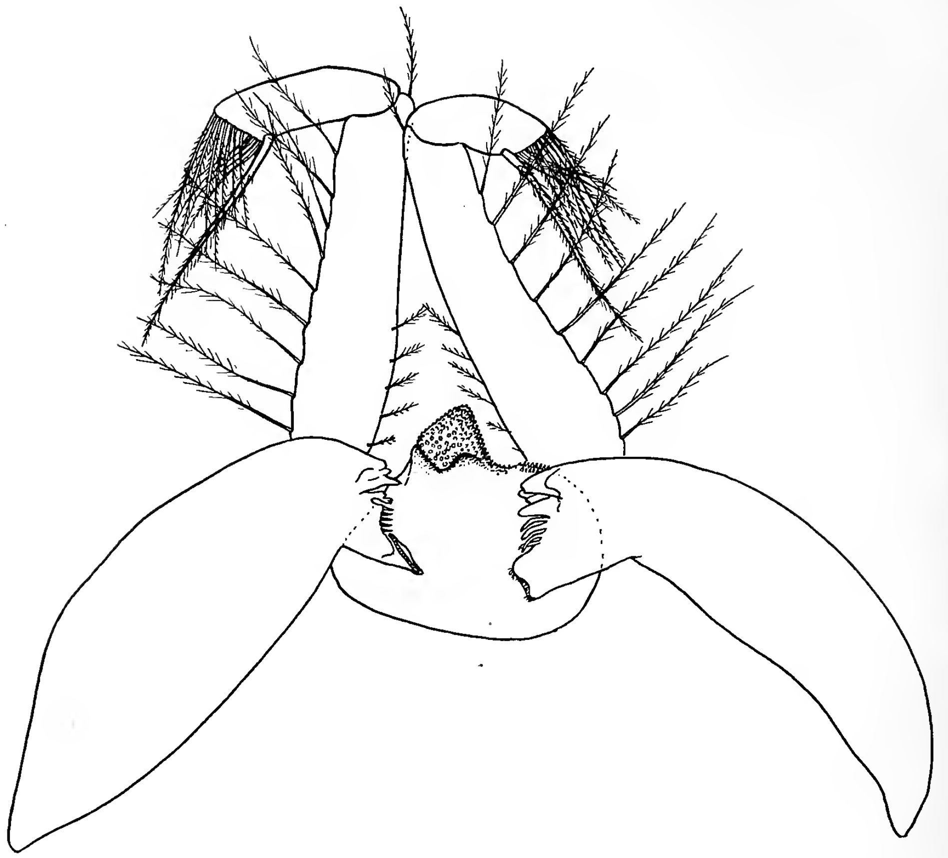
Occurrence :

St. 61 C–D. N. 100. 1500–0 m. 1702 m.w.o. Two females, 12 mm.

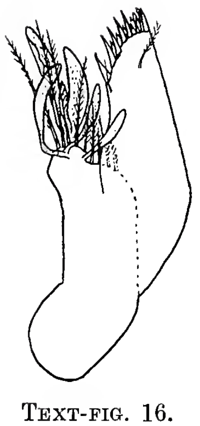
Description.—Integument thin and membranous. Carapace covering the whole of the thorax; rostral plate (Text-fig. 14) hardly developed at all, the front margin of the carapace being broadly and evenly rounded and somewhat upturned, so that the whole of the eyes and eyestalks and the region between them and the bases of the antennules and antennæ are exposed, antero-lateral corners rounded and not produced. Eyes (Text-fig. 14)



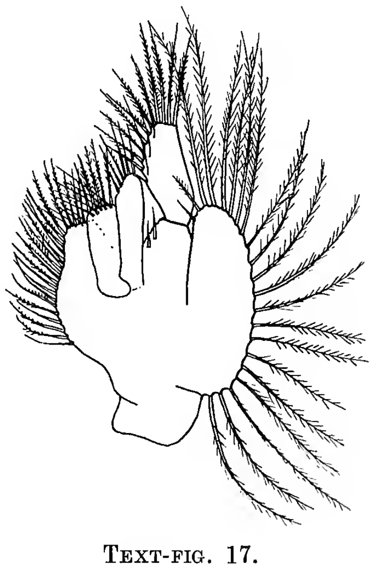
Text-fig. 14.—*Thalassomysis sewelli* gen. et sp. nov. Dorsal view of anterior end. × 24.



TEXT-FIG. 15.



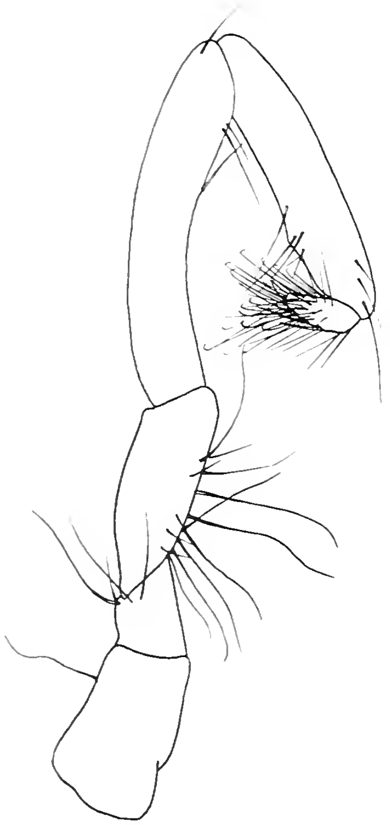
TEXT-FIG. 16.



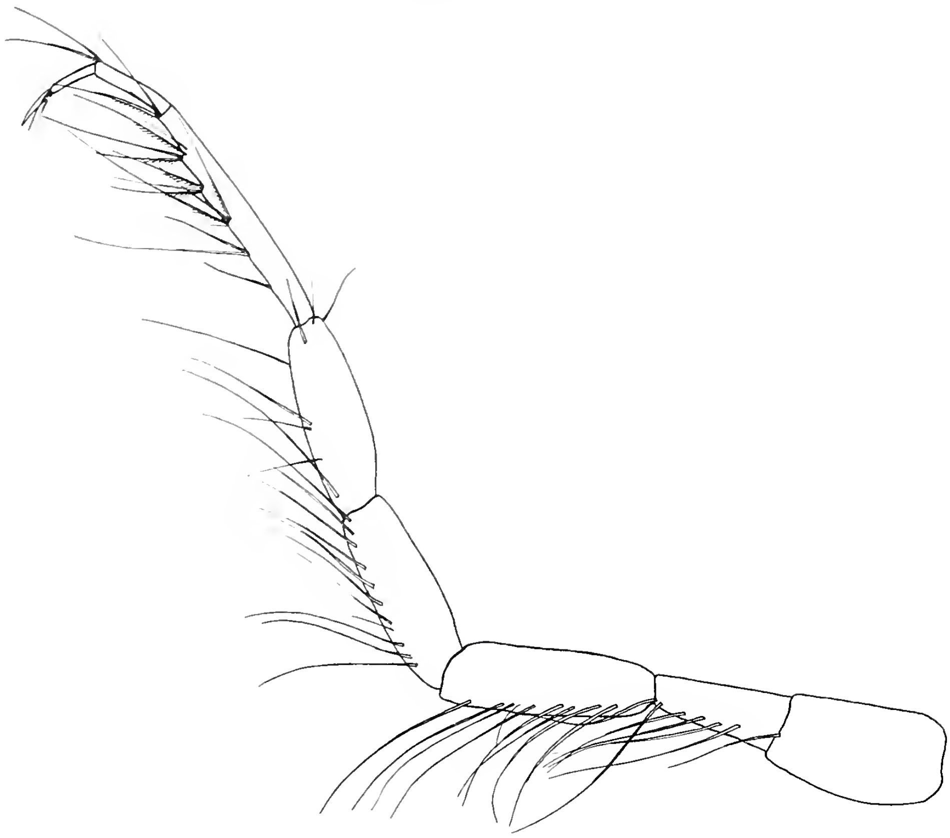
TEXT-FIG. 17.

TEXT-FIG. 18.

TEXT-FIGS. 15–18.—*Thalassomysis sewelli* gen. et sp. nov. FIG. 15.—Right and left mandibles and labrum viewed from below. × 50. FIG. 16.—Maxillule. × 50. FIG. 17.—Maxilla. × 40. FIG. 18.—Endopod of the first thoracic limb. × 40.



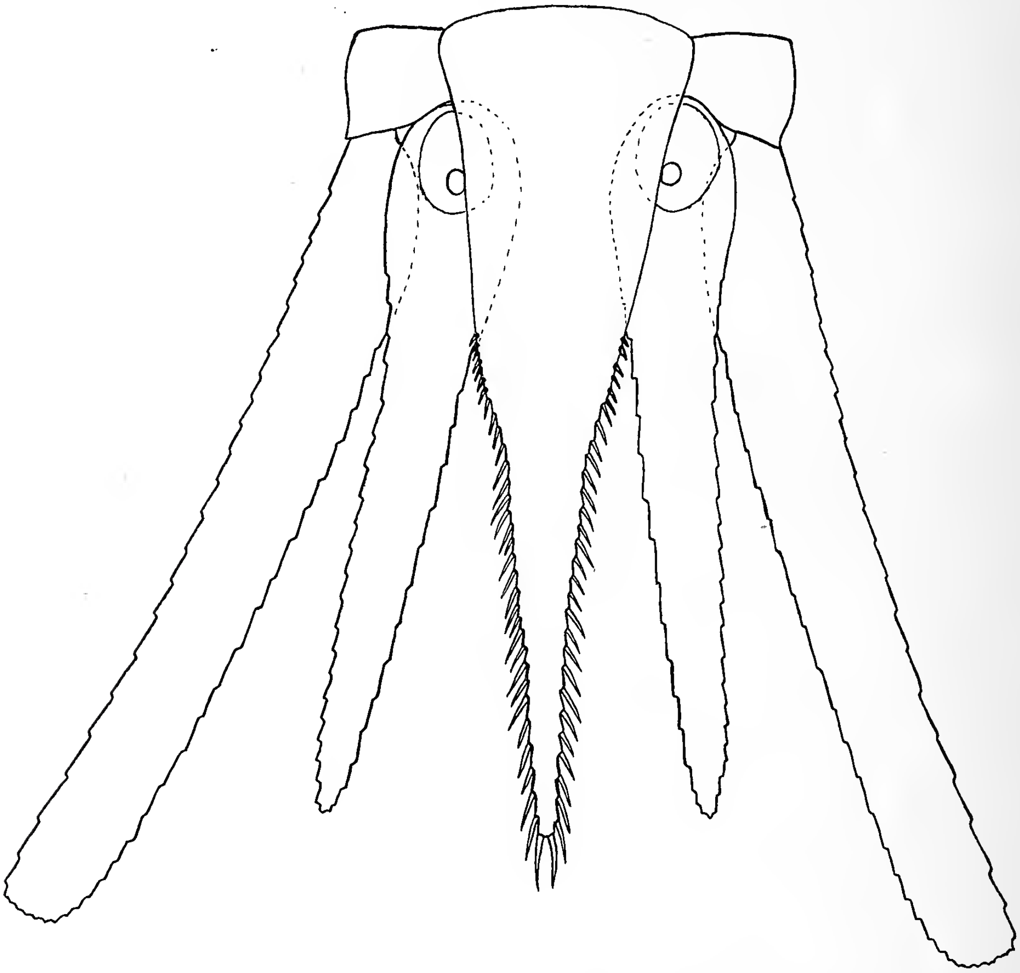
Text-fig. 19.



Text-fig. 20.

Text-figs. 19, 20.—*Thalassomysis sewelli* gen. et sp. nov. Fig. 19.—Endopod of the second thoracic limb. × 26. Fig. 20.—Endopod of the third thoracic limb. × 26.

small and flattened, most of the cornea on the under-side so that in dorsal view only a narrow arc of cornea is visible; a small ocular papilla situated on the inside of the stalk at the margin of the cornea, pigment dark brown. Second joint of the antennular peduncle exceptionally short. Antennal scale (Text-fig. 14) extending for one-quarter of its length beyond the antennular peduncle, at least six times as long as broad at its widest part, narrowly oval in shape and somewhat narrower in the centre than at either end, setose all round, the setæ very long and slender. Antennal peduncle (Text-fig. 14) shorter than



Text-fig. 21.—*Thalassomysis sewelli* gen. et sp. nov. Telson and uropods. × 40.

the antennular; second joint short and narrower than the first and third, the third joint with a well-developed backwardly directed lobe overlying the second joint. Labrum (Text-fig. 15), mandibles (Text-fig. 15) and maxillulæ (Text-fig. 16) as in the generic definition. Terminal joint of the palp of the maxillæ (Text-fig. 17) two and a half times as long as broad. First thoracic limbs with both exopod and epipod; endopod (Text-fig. 18) with a well-developed gnathobasic lobe from the second joint. Second thoracic limb with well-developed exopod; endopod (Text-fig. 19) moderately long and robust, fifth joint longer than the sixth, sixth joint with a feebly developed palmar margin on the inner distal side, seventh joint short and thick, densely setose and terminating in a short claw. Endopods of the remaining thoracic limbs (Text-fig. 20) long and slender, sixth joint subdivided into three subjoints by two vertical articulations, the first subjoint about twice as long as the other two combined. Last thoracic somite nearly twice as long as the fifth. Telson (Text-fig. 21) longer than the sixth abdominal somite, six times as long as broad at its base, very elongate and narrowly triangular in shape, longer than the inner uropod, but shorter than the outer; distal two-thirds of its lateral margins armed with about thirty rather long spines; apex narrowly truncate and armed with one pair of spines, which are about three times as long as the apex is broad; no apical plumose setæ. No spines on the inner margin of the inner uropods. Length of an adult female, 12 mm.

Remarks.—The distinguishing features of this interesting species are to be found in the antennal scale and the telson. The combination of these two characters is quite unlike anything else to be found in the group. The peculiar labrum and maxillulæ also serve to differentiate it from any other species. It is the most interesting Mysid in the collection.

Genus *Euchaetomera* G. O. Sars.

Euchaetomera typica G. O. Sars.

Euchaetomera typica, G. O. Sars, 1885; Tattersall, 1911 (2); Illig, 1930.
Brutomysis vogtii, Chun, 1896.
Euchaetomera limbata, Illig, 1906 (1).
Euchaetomera sennæ, Colosi, 1920.

Occurrence:

St. 172. N. 100. 200–0 m. 510 m.w.o. One.

Distribution.—This species has been recorded from the Indian Ocean by Tattersall (1911 (2)) and Illig (1930). It has a world-wide distribution in the tropical and subtropical waters of the globe.

Euchaetomera tenuis G. O. Sars.

Euchaetomera tenuis, G. O. Sars, 1885; Hansen, 1910 and 1912; Zimmer, 1914; Illig, 1930.
Euchaetomera fowleri, Holt and Tattersall, 1905.

Occurrence:

St. 131 D. N. 100. 500–0 m. One female, 11 mm.

Distribution.—This species has been recorded from the Indian Ocean by Illig. It has a similar distribution to that of *E. typica*.

Euchaetomera oculata Hansen.

Euchaetomera oculata, Hansen, 1910; Tattersall, 1911 (2); Illig, 1930; Coifmann, 1936 (2).

Occurrence:

St. 96. N. 200. 400–645 m. 900 m.w.o. One female, 7 mm.

Remarks.—This species is known only from the Indian and Pacific Oceans. It has been recorded from the Indian Ocean by Tattersall (1911 (2)), Illig (1930), and Coifmann (1936 (2)).

Euchaetomera glyphidophthalma Illig.

Euchaetomera glyphidophthalma, Illig, 1906 (1); Zimmer, 1914; Illig, 1930.

Occurrence:

St. 186. N. 100. 575–0 m. 880 m.w.o. One female, 8 mm.

Distribution.—This is the first record from the Indian Ocean. All Illig's material came from the Atlantic Ocean, and the species has also been recorded from the Mediterranean by Zimmer and Colosi.

Genus *Echinomysis* Illig.

Echinomysis chuni Illig.

Echinomysis chuni, Illig, 1905 (2), 1912 and 1930.

Occurrence :

St. 172. N. 100. 400–0 m. 820 m.w.o. One female, 11 mm.

Remarks.—The single specimen is in complete agreement with Illig's description and figures. Coifmann (1936 (2)) has described a second species of the genus, *E. distinguenda*, from the Gulf of Aden on the evidence of a single male specimen. It is very closely allied to *E. chuni*, but much more material is necessary before it can be decided whether the very trivial differences between the two forms have a real specific value.

Distribution.—Illig (1930) records this species from eight stations altogether, seven in the Indian Ocean (five within the area covered by this report) and one in the Atlantic Ocean, in the Gulf of Guinea off Lagos.

Genus *Gibberythrops* Illig.

Illig (1906 (1)) described two species of Mysids from the Indian Ocean in the neighbourhood of Aden under the names *Parerythrops acanthura* and *Erythrops brevisquamosa*. In 1930 he made the former species the type of a new genus, *Gibberythrops*, and referred the latter species, with some doubt, to the genus *Hypererythrops*. Coifmann (1936 (2)), who examined the same two species from material collected in the same locality, referred both species to the genus *Erythrops* on the grounds that the pleopods of the male conform to the type met with in males of that genus, and that *E. brevisquamosa* did not possess the scythe-like spines on the sterna of the thoracic somites of the male which are characteristic of the genus *Hypererythrops*. Coifmann, however, retained the genus *Gibberythrops* as a sub-genus of *Erythrops* for *E. acanthura*. Neither species, however, has the kidney-shaped eyes or the characteristic telson of the genus *Erythrops*, and it is doubtful whether they can legitimately remain in that genus. Both are small-eyed forms with the general aspect of species of the genus *Katerythrops*, but again the form of the telson precludes certain reference to that genus. For the present it seems best to retain the genus *Gibberythrops* for *P. acanthura* Illig, and to refer *E. brevisquamosa* Illig to the same genus. The two species are closely allied, having the same type of eye, antennal scale and telson. I can confirm Coifmann's account of the two species, in so far as the relatively poor state of preservation of my material allows.

Gibberythrops acanthura (Illig).

Parerythrops acanthura, Illig, 1906 (1).
Gibberythrops acanthura, Illig, 1930.
Erythrops (*Gibberythrops*) *acanthura*, Coifmann, 1936 (2).

Occurrence :

St. 96. N. 200. 400–645 m. 900 m.w.o. One male, 6·5 mm.

St. 186. N. 100. 575–0 m. 880 m.w.o. Two females, 6–7 mm.

St. 186. N. 100. 600–0 m. 1150 m.w.o. One male, 6 mm.

Distribution.—This species is only known from the Indian Ocean.

Gibberythrops brevisquamosa (Illig).

Erythrops brevisquamosa, Illig, 1906 (1) ; Coifmann, 1936 (2).
Hypererythrops brevisquamosa, Illig, 1930.

Occurrence :

St. 186. N. 100. 600–0 m. 1150 m.w.o. One male, 6 mm.

Distribution.—Like the last species, this form is only known from the Indian Ocean.

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BRITISH MUSEUM (NATURAL HISTORY)

THE

JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME V, No. 9

ASCOTHORACICA

(CRUSTACEA, CIRRIPEDIA)

BY

K. A. PYEFINCH, M.A.

(*University College, Nottingham*)

WITH TWENTY TEXT-FIGURES

LONDON:
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AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W.7
1939

Price Two Shillings

[*Issued 22nd July, 1939*]

DESIGNED AND
PRINTED
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Made and printed in Great Britain

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INTRODUCTION.

These parasitic Cirripedes have been recorded from a number of hosts, Zoanthidea, Antipatharia and Echinodermata, since the description of *Laura gerardiæ*, from *Gerardia lamarcki*, by Lacaze-Duthiers in 1882. Norman (1888, 1913) has described *Synagoga mira*, an external parasite on *Antipathes larix*; Fowler (1889), *Petrarca bathyactidis* within *Bathyactis symmetrica*; Knipowitsch (1891), *Dendrogaster* within *Echinaster sarsi* and *Solaster papposus*; Djakonov (1914), *Ascothorax ophioctenis* within *Ophiocten sericeum*; Okada (1925), *Myriocladus* from *Asteroids* and Brattström (1936), *Ulophysema* from *Echinocardium cordatum*. Moreover, since the description of *Baccalaureus japonicus* by Broch in 1929, a number of descriptions of various species of this genus have appeared (Pyefinch, 1934, 1936, 1937; Brattström, 1936).

Most of these species have been founded upon a small number of specimens, so that the collections of Zoanthidea, Antipatharia and Echinodermata, made by the "John Murray" Expedition, presented a unique opportunity for the examination of a range of hosts, collected from one area, likely to contain these parasites. Unfortunately, only the Zoanthids contained any Ascothoracica, and all the specimens found may be included within the genus *Baccalaureus* (Broch). The complete list is as follows:

Baccalaureus japonicus (Broch).
B. disparcaudatus sp. nov.
B. verrucosus sp. nov.
B. digitatus sp. nov.

There were seven specimens of *B. japonicus*; two of *B. disparcaudatus*, and one each of *B. verrucosus* and *B. digitatus*. *B. japonicus*, the only species in the collection that was known previously, had not been recorded from the Indian Ocean, though related species have been described from the Maldives (*B. maldivensis*, Pyefinch, 1934), and from Madagascar (*B. argalicornis*, Brattström, 1936). The discussion of the relationships between the new species described in this report is continued later, after the description of the material examined.

Genus *Baccalaureus* Broch, 1929.

In the description of the species of this genus, the nomenclature adopted in the descriptions of *B. maldivensis*, *B. hexapus* and *B. torrensis* has been followed. That is, the elongated processes arising from the anterior end of the body are termed antennules, the plate-like structures at the side of the anterior end of the body are termed antennæ, and the appendages projecting backwards from the sides of the oral cone, the first pair of thoracic appendages. Yosii (1931) in his account of *B. japonicus* has adopted a different nomenclature, and in particular describes the last-named appendages as antennules. Brattström (1936) has followed Yosii's nomenclature in his description of *B. argalicornis*. The precise identity of all the structures mentioned above is still very much in doubt, so that the terminology adopted in the present instance is only tentative. On the other hand, there are inconsistencies in Yosii's description which make his identification of these various anterior processes and appendages doubtful. This point has been discussed previously (Pyefinch, 1936).

Baccalaureus japonicus (Broch). (Text-figs. 1–7.)

Baccalaureus japonicus Broch, 1929, 5 text-figs.; Yosii, 1931, 4 pls.

Occurrence.—Sta. 105B, Zanzibar area, depth 238 m. Two specimens each within a polyp of a Zoanthid (not yet determined).

Sta. 106, Zanzibar area, depth 212 m. Five specimens. Two of these specimens occurred, side by side, within the same polyp, each of the remaining three specimens occurring alone.

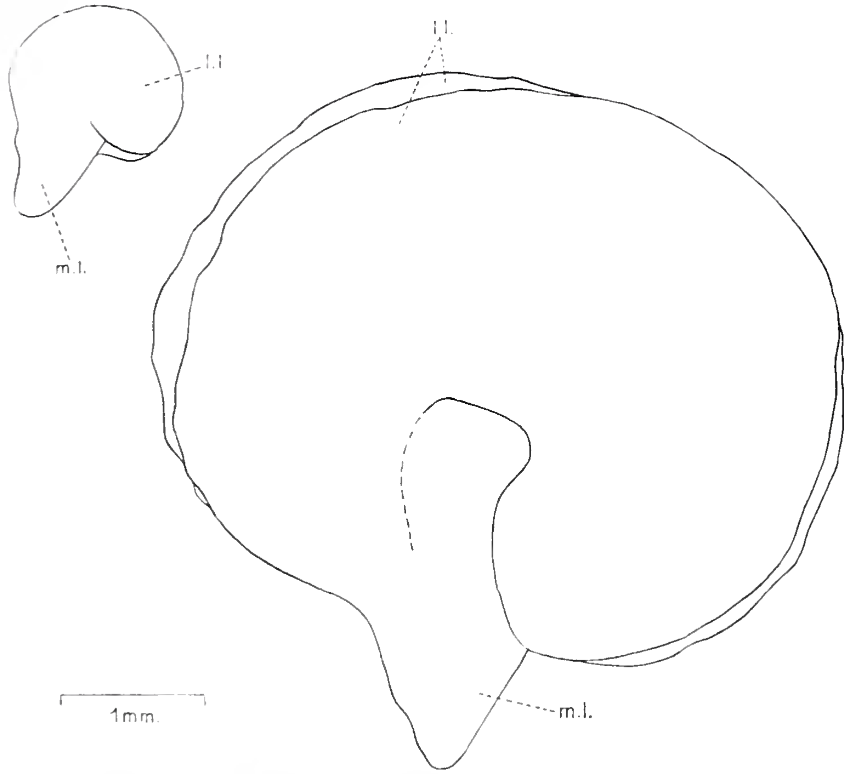
Remarks.—All these seven specimens have been included within the species *japonicus*, though it is with considerable hesitation that they have been grouped together in this way. All the specimens agree with the published descriptions of this species in the following characters:

(*a*) The degree of coiling of the lateral mantle lobes.
(*b*) The number of thoracic appendages.
(*c*) The number of terminal spines upon the rami of the caudal fork.
(*d*) The extent and general form of the lateral chitinous ridge.

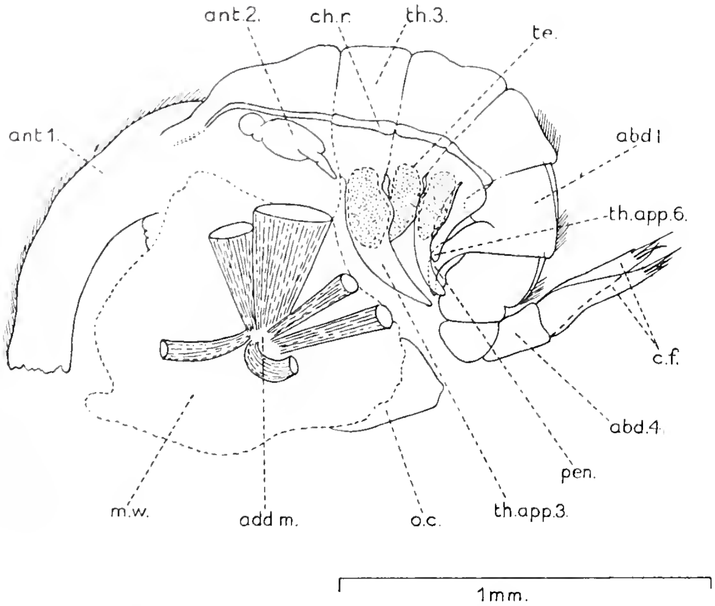
Of these four characters, only the second and third can be considered to be of any significance. In view of the lack of correlation between the degree of coiling of the lateral mantle lobes and the anatomy of the segmented body of these parasites (*vide* Pyefinch, 1937), the first character is only of general significance, whereas the fourth character is one which is general throughout the genus *Baccalaureus*.

The difficulty of precise identification is increased by the lack of uniformity in the descriptions given by Broch and Yosii. These differences are discussed below.

Both Broch and Yosii state that they were able to distinguish four thoracic segments, though these segments are not always clearly shown in the accompanying figures (*e. g.* Broch, fig. 5, p. 241). In the present instance only three thoracic segments were clear (Text-fig. 2). The arrangement of the appendages on these segments also differs in the two previous accounts. Yosii (1931) describes one pair of appendages as attached to each of the four thoracic segments, and this arrangement is also shown in his figures (pl. ix, fig. 4), but Broch (1929) draws the last two pairs of appendages as attached to the last thoracic

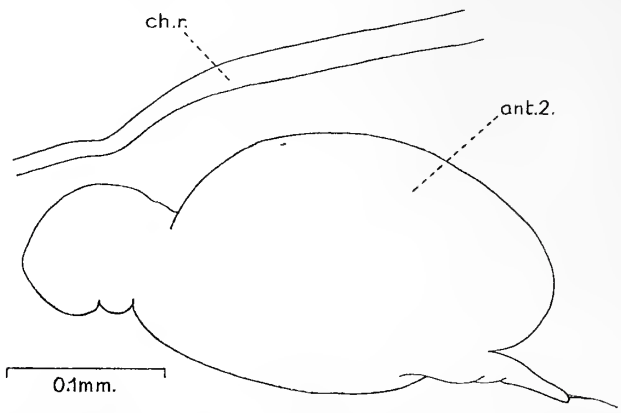


TEXT-FIG. 1.—*Baccalaureus japonicus* Broch. Whole specimens from the side, showing the degree of coiling of the lateral mantle lobes in a large and a small specimen. *l.l.*, lateral lobes of mantle. *m.l.*, median lobe of mantle.



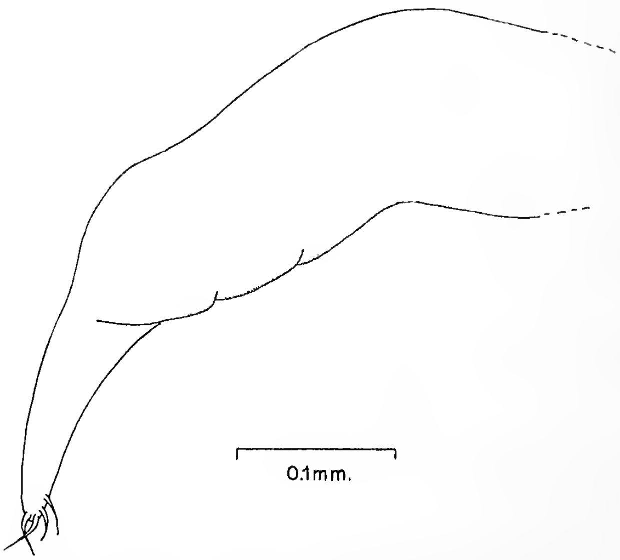
TEXT-FIG. 2.—*Baccalaureus japonicus* Broch. Segmented body from the left-hand side. (The "first thoracic appendage" is not shown.) *abd.*1., *abd.*4., 1st and 4th abdominal segments. *add.m.*, adductor muscle. *ant.*1, antennule (?). *ant.*2, antenna (?). *c.f.*, caudal fork. *ch.r.*, chitinous ridge. *o.c.*, oral cone. *pen.*, penis. *te.*, testis. *th.*3, 3rd thoracic segment. *th.app.*3, etc., thoracic appendages.

segment. This is clearly shown in his fig. 5 (p. 241), but is less clear in the preceding text-figure (p. 240). The Murray specimens here agree with Broch's description, as the last two thoracic appendages on each side are attached to the last thoracic segment. (Text-fig. 2.) Thus this segment probably represents segments 5 and 6 of the primitive thorax. The preceding two thoracic segments (4, 3) each bear a single pair of appendages.



Text-fig. 3.—*Baccalaureus japonicus* Broch. Antenna (?) of the left-hand side. Lettering as before.

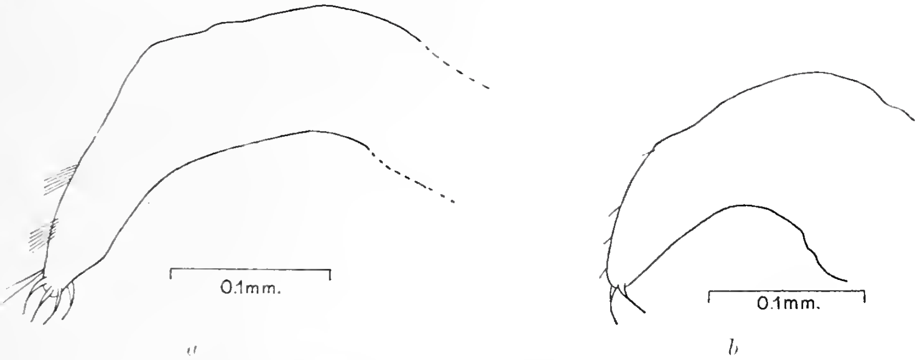
Each ramus of the caudal fork ends in three spine-like setæ, that situated towards the dorsal side being in each case the longest (Text-fig. 6). This arrangement agrees with that figured by Broch, but not with the figures given by Yosii, who draws the three setæ as being equal in length (pl. ix, figs. 4, 5).



Text-fig. 4.—*Baccalaureus japonicus* Broch. Third thoracic appendage of the left-hand side.

In the present series of specimens setæ are present on the dorsal surface of the last thoracic segment and on abdominal segments 1 and 2, an arrangement agreeing with the description given by Yosii. Broch, however, in fig. 4 (p. 240), shows setæ on the last thoracic and first abdominal segments, but in fig. 5 they are drawn as present on the first two abdominal segments.

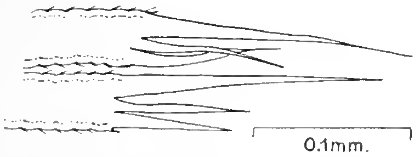
Both Broch and Yosii have described the plate-like structure lying near the chitinous ridge at the anterior end of the body (blasenformige Anschwellung: fan-shaped appendage). In one of the present series of specimens this structure could be seen to end posteriorly in a finger-like process, with a single seta at its tip (Text-figs. 2, 3). A posterior



TEXT-FIG. 5.—*Baccalaureus japonicus* Broch. Posterior thoracic appendages. *a*, Fifth thoracic appendage. *b*, Sixth thoracic appendage.

process similar to this lateral structure has been described in *B. argalicornis* (Brattström, 1936) and in *B. torrensis* (Pyefinch, 1937).

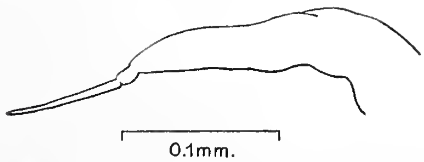
Projecting backwards, at the side of the oral cone, is a simple appendage, unjointed and with a spine-like tip. Broch does not describe any appendage as occurring in this position in his material, but Yosii described a jointed appendage, which he has termed the



TEXT-FIG. 6.—*Baccalaureus japonicus* Broch. Rami of caudal fork, showing arrangement of terminal spines.

antennule. As has been mentioned earlier in the present instance, this appendage has been termed first thoracic appendage (Text-fig. 7).

Nauplii were only present in one specimen (from Sta. 106). Yosii has described " frontal processes " as occurring in the nauplii of *B. japonicus*, but it was not possible to identify these in every nauplius in the present case. This series of nauplii further differed



TEXT-FIG. 7.—*Baccalaureus japonicus* Broch. First thoracic appendage of the right-hand side. Drawn from another specimen.

from those described by Yosii in their smaller size (0·27 mm. long by 0·18 mm. broad, as against 0·4 mm. long by 0·3 mm. broad).

In all the specimens examined, both large and small, the form of the lateral mantle lobes was much more rounded than that of the specimens described by Broch and Yosii. This difference is probably not of great importance, as the form of the mantle may well depend upon the position taken up by the parasite within its host. All the specimens in this case were found within the cœlenteron of the host Zoanthid, so that growth of the mantle might be expected to be regular.

Thus the characters in which the present series of specimens differ from *both* the earlier accounts are :

(*a*) The form of the mantle lobes.
(*b*) The dimensions of the nauplii.
(*c*) The absence, in some cases, of " frontal processes " in the nauplii.

In view of the differences between the descriptions of *B. japonicus* given earlier and the present lack of knowledge of the validity of the specific distinctions made within the genus *Baccalaureus*, it would be unwise to place the present series of specimens in a new species on the basis of the differences enumerated above.

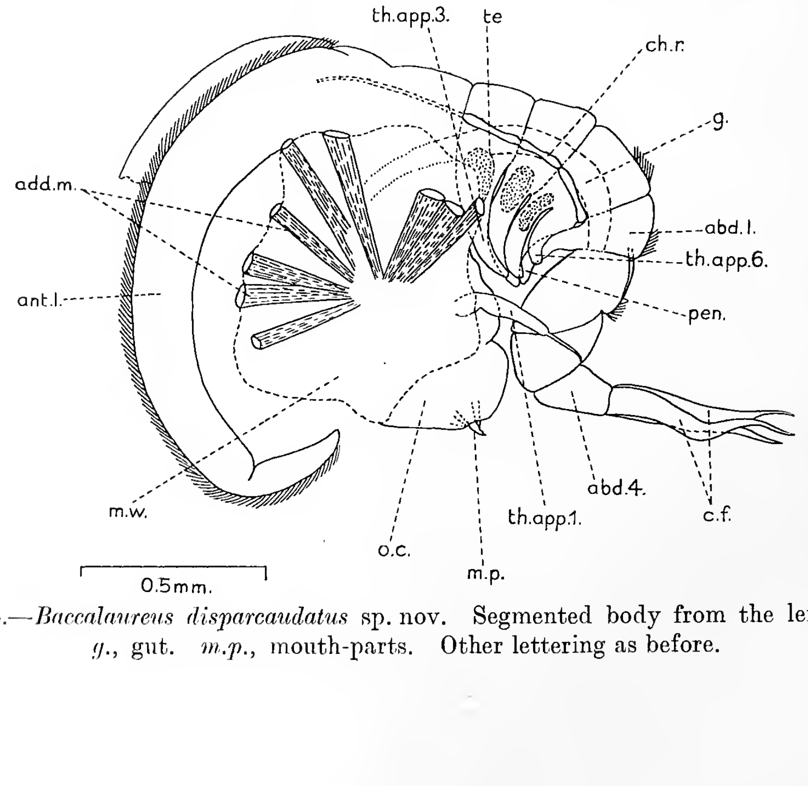
Since there is some doubt about the morphology of *B. japonicus*, text-figures have been included in this account (Text-figs. 1–7) showing details of external form, the segmented body, the thoracic appendages and of the rami of the caudal fork.

Baccalaureus disparcaudatus sp. nov. (Text-figs. 8–10).

Occurrence.—Sta. 106, Zanzibar area, depth 183–194 m. Two specimens, both embedded transversely within the cœlenteron of a single polyp of a Zoanthid (not yet determined).

Diagnosis.—Mantle with median and lateral lobes, the latter slightly coiled. Tip of median lobe pointed. Segmented body with three free thoracic segments and four abdominal segments. Thoracic appendages uniramous and unsegmented ; a single pair on each of the first two free thoracic segments, the last thoracic segment with two pairs of appendages. Dorsal setæ present on the last thoracic and the first two abdominal segments. Penis on the ventral surface of the first abdominal segment. Biramous caudal fork, the upper ramus ending in three setæ, the lower ramus curved and ending in a single large seta.

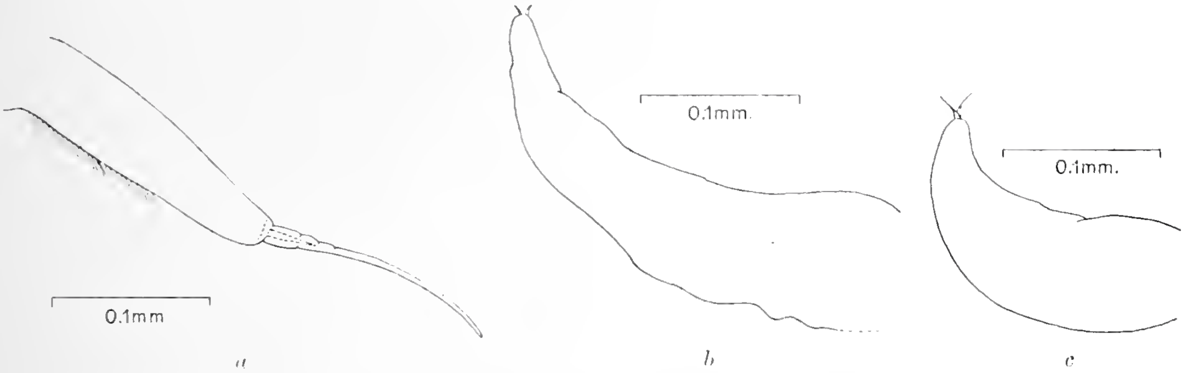
Description.—This species is closely allied to *Baccalaureus japonicus*, and in many



Text-fig. 8.—*Baccalaureus disparcaudatus* sp. nov. Segmented body from the left-hand side. *g.*, gut. *m.p.*, mouth-parts. Other lettering as before.

respects it agrees closely with the descriptions given of the latter species, notably in the form of the mantle, the degree of coiling of the lateral mantle lobes, the form of the antennules (anterior processes), the number and arrangement of the thoracic appendages, the position of the dorsal setæ and the position of the penis.

It differs, however, in three respects. The form of the rami of the caudal fork is very distinctive. The upper ramus is normal in form, and ends in three setæ, of which

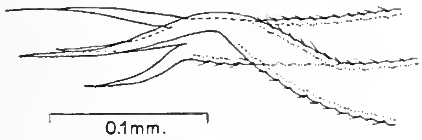


Text-fig. 9.—*Baccalaureus disparcaudatus* sp. nov. Thoracic appendages. *a*, First thoracic appendage, left-hand side. *b*, Fourth thoracic appendage, right-hand side. *c*, Sixth thoracic appendage, right-hand side.

the dorsal is slightly longer than the other two, but the lower ramus bends upwards so as to overlap the upper ramus, and it ends in a single large spine (Text-figs. 8, 10).

The number of setæ on the thoracic appendages is also reduced and the setæ themselves are much smaller than those of *Baccalaureus japonicus* (Text-fig. 9 *a*, *b*, *c*. Compare Text-figs. 4 and 5).

Thirdly, no plate-like structure could be detected at the side of the anterior part of the thorax, although this region was carefully examined.



Text-fig. 10.—*Baccalaureus disparcaudatus* sp. nov. Caudal fork.

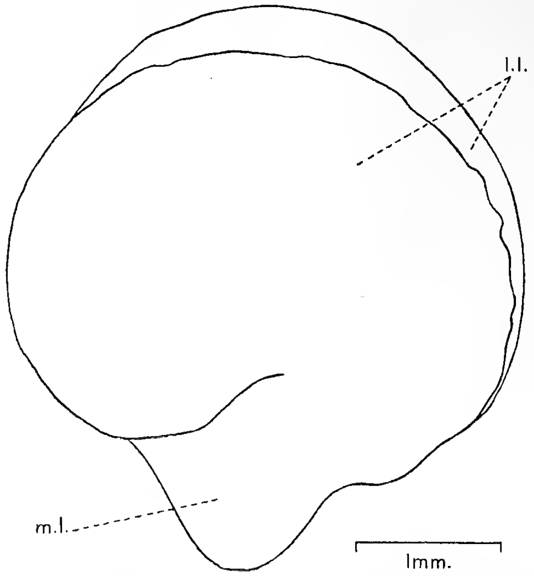
Remarks.—The three differences outlined above seem sufficient to place these specimens in a new species, though it would appear likely that they are allied to *Baccalaureus japonicus*. The proposed name "disparcaudatus", refers to the form of the rami of the caudal fork.

Baccaalureus verrucosus sp. nov. (Text-figs. 11–16.)

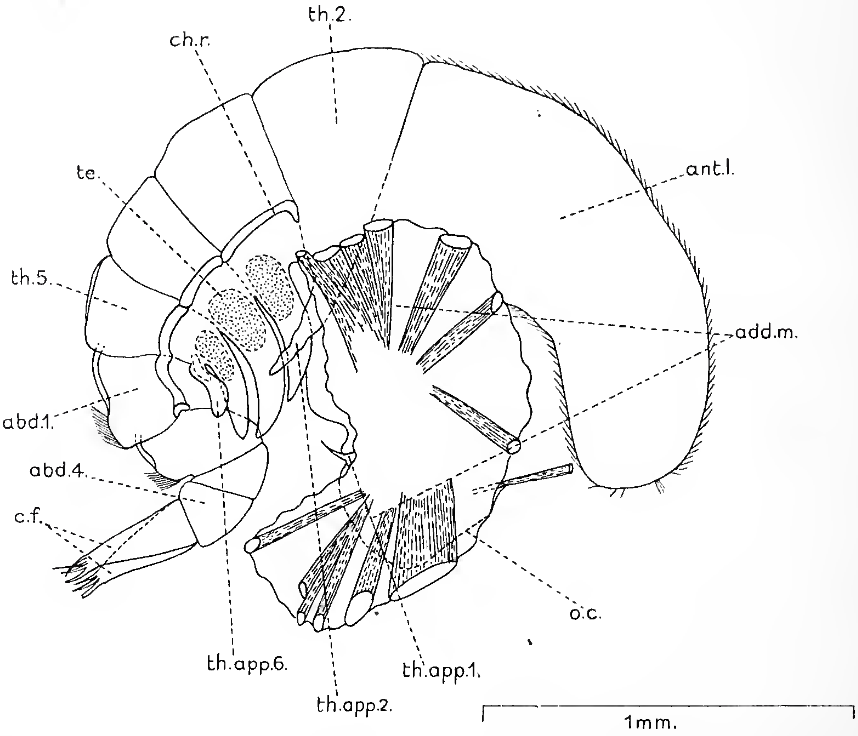
Occurrence.—Sta. 122, Zanzibar area, depth 762 m. One specimen, from the stolon between two polyps of a Zoanthid (not yet determined).

Diagnosis.—Mantle with median and lateral lobes, the latter slightly coiled. Surface of mantle lobes with well marked papillæ. Tip of median lobe broad. Segmented body with four free thoracic segments and four abdominal segments. Thoracic segments 2–4 (inclusive) each with one pair of uniramous, unsegmented appendages. Thoracic segment 5 with two pairs of appendages. Penis on the ventral surface of abdominal segment 2.

Biramous caudal fork, each ramus bearing four setæ, the lowermost of these being the stoutest. Dorsal setæ on abdominal segments 1 and 2. Anterior processes broad and short.



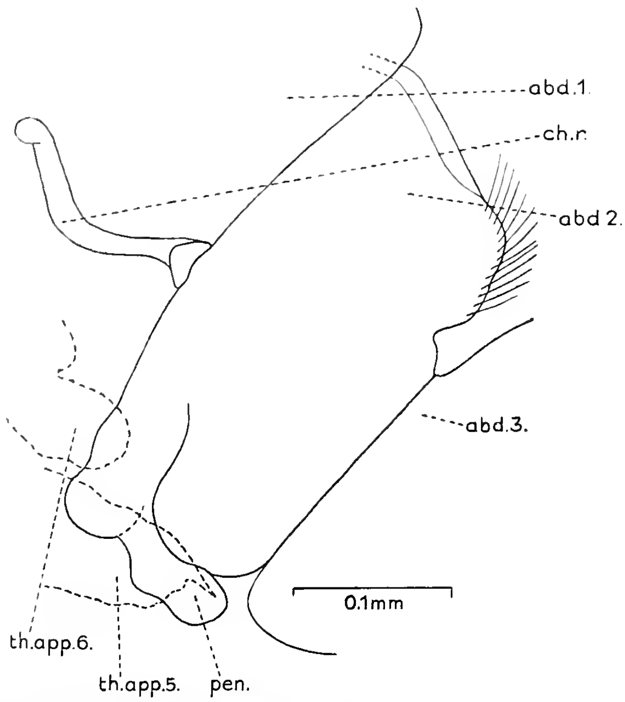
TEXT-FIG. 11.—*Baccalaureus verrucosus* sp. nov. Whole specimen. Lettering as before.



TEXT-FIG. 12.—*Baccalaureus verrucosus* sp. nov. Segmented body from the right-hand side. Lettering as before.

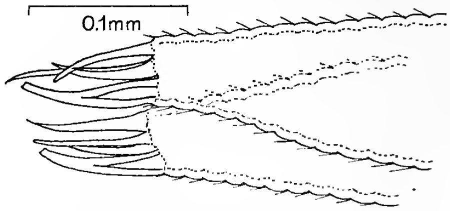
DESCRIPTION.—The most conspicuous features of the external appearance of this specimen are the globular shape of the mantle as a whole and the presence of large papillæ on its surface. The degree of coiling of the lateral mantle lobes approximates to that of *B. japonicus*, but the more globular form of the mantle is distinctive (Text-fig. 11). The

TEXT-FIG. 13.—*Baccalaureus verrucosus* sp. nov. Thoracic appendages. *a*, First thoracic appendage. *b*, Second thoracic appendage. *c*, Third thoracic appendage. *d*, Fourth thoracic appendage. *e*, Fifth thoracic appendage. *f*, Sixth thoracic appendage.



TEXT-FIG. 14.—*Baccalaureus verrucosus* sp. nov. Details of insertion of penis. Lettering as before.

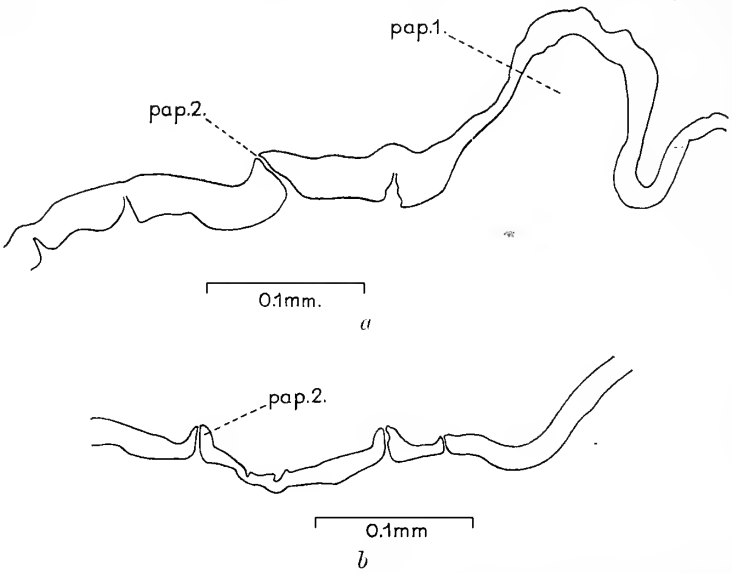
large papillæ which beset the surface of the mantle also contribute to this distinctive appearance. It would appear improbable that these papillæ are homologous with the papillæ found in other species of *Baccalaureus* since in section (Text-fig. 16*a*, *pap.* 1), they can be seen to lack the characteristic duct. The more normal type of papilla (Text-fig. 16*a*,



TEXT-FIG. 15.—*Baccalaureus verrucosus* sp. nov. Caudal fork.

pap. 2) lie scattered between these larger projections. The condition in this species may be compared with the more normal type of mantle wall (Text-fig. 16*b*).

The orientation of the segmented body within the mantle is similar to that of species previously described. The anterior processes (Text-fig. 12, *ant.* 1) are particularly short and stout, a condition presumably correlated with the globular form of the mantle. There is an oral cone of the usual form, at the side of which is a small appendage (Text-fig. 12, *th. app.* 1) projecting backwards. Owing to the mass of the adductor muscle, the proximal



TEXT-FIG. 16.—Mantle wall of *Baccalaureus verrucosus*, compared with that of a more normal species. *a*, *Baccalaureus verrucosus* sp. nov. *b*, *Baccalaureus disparcaudatus* sp. nov. *pap.*1. large papillæ. *pap.*2, smaller papillæ, pierced by a canal.

parts of this appendage could not be traced, but it ends distally (Text-fig. 13*a*) in two stout spine-like processes. The second to fifth thoracic appendages are, in several respects, similar. So far as could be made out, each ends in three stout setæ (Text-fig. 13*b*, *c*, *d* and *e*), and their posterior edges are clothed with a row of finer setæ. The sixth thoracic appendage is much smaller than those preceding, and lacks the terminal setæ. The second thoracic appendage projects backwards, overlapping appendages 3 and 4. Testes occur proximally on the third, fourth and fifth thoracic appendages. From the fact that the last thoracic segment bears two pairs of appendages, it would seem that this represents the fused fifth and sixth segments of the primitive thorax.

The abdomen is of the normal form, the second segment bearing a stout penis in the mid-ventral line (Text-fig. 14). The general form of the rami of the caudal fork resembles that of other species of *Baccalaureus*, and their edges are beset with short setæ, set in shallow pockets of the integument (Text-fig. 15). There are, however, four terminal spines on each ramus, the ventral member of each series being the stoutest (Text-fig. 15).

The lateral chitinous ridge can be traced running along the side of the abdomen and thorax. Posteriorly it ends abruptly at the posterior edge of the first abdominal segment and anteriorly it cannot be traced further forwards than the anterior edge of the third thoracic segment.

Remarks.—This specimen was found embedded within the stolon between two polyps, its position within its host being thus abnormal. The segmentation of the thorax and the arrangement of the thoracic appendages recalls the condition found in *B. torrensis* Pyefinch, 1937), but it cannot be suggested that the present specimen is closely allied to the latter species.

The specific name adopted for this specimen refers to the appearance of the mantle surface.

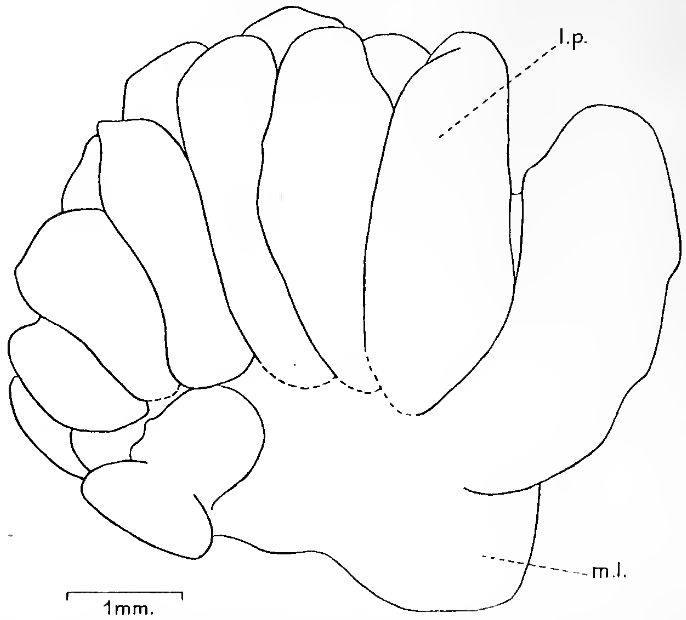
Baccalaureus digitatus sp. nov. (Text-figs. 17–20.)

Occurrence.—Sta. 184, Gulf of Aden, depth 1270 m. One specimen within a polyp of a Zoanthid (not yet determined).

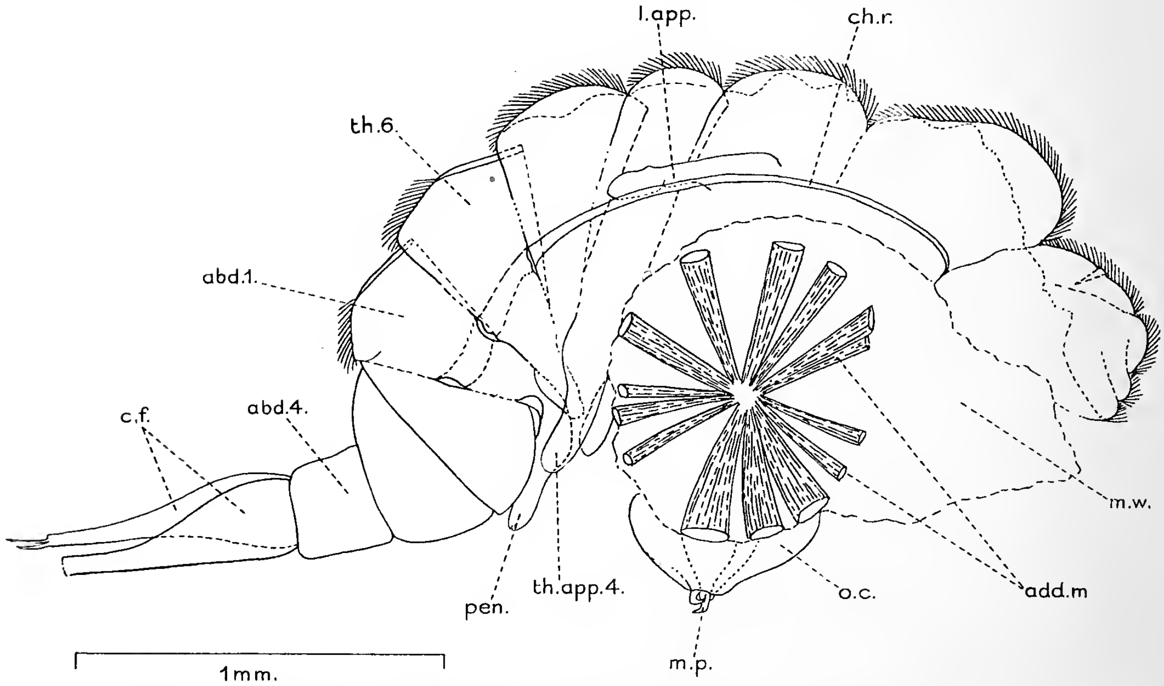
Diagnosis.—Mantle indistinctly divided into median and lateral lobes. The more median part of normal form, the more lateral part produced into eight pouches on each side. Segmented body large with four abdominal segments and six (?) free thoracic segments. At least three pairs of broad, uniramous, unjointed thoracic appendages, on segments 3, 4 and 5. Penis on the ventral surface of the first abdominal segment. Biramous caudal fork, each ramus probably bearing three setæ. Lateral chitinous ridge broad posteriorly, narrower anteriorly. Dorsal setæ present on the first abdominal segment and on all the thoracic segments. Anterior processes absent.

Description.—This specimen is especially distinct, as the form of the mantle differs radically from that of any other species of *Baccalaureus*. The median lobe is more normal in form but, instead of the coiled lateral lobes found in other species, the mantle is in this instance produced into eight paired pouches, the cavities of which are in free communication with the cavity of the median mantle lobe (Text-fig. 17). The segmented body lies within this mantle along its floor and it is attached to the latter by the adductor muscle (Text-fig. 18, *add. m.*). The orientation of the segmented body within the mantle is fundamentally the same as in other species of the genus, that is, the abdomen points towards the opening of the median mantle lobe (towards the right in Text-fig. 17).

The segmented body is much larger than that of any species previously recorded (roughly 3 mm. long), and is particularly characterized by the rounded appearance of the dorsal edges of the thoracic segments. There are no anterior processes (antennules), but there are irregular processes on the anterior edge of the most anterior segment (Text-fig. 18). It was not possible to determine whether this segment represented the first thoracic segment alone, or the first thoracic segment fused with the head. The second alternative seems the more probable. The oral cone, projecting below the adductor muscle, is well developed (Text-fig. 18, *o.c.*), and projecting backwards at the side of the oral cone is an appendage which closely resembles the appendage termed 1st thoracic in other species



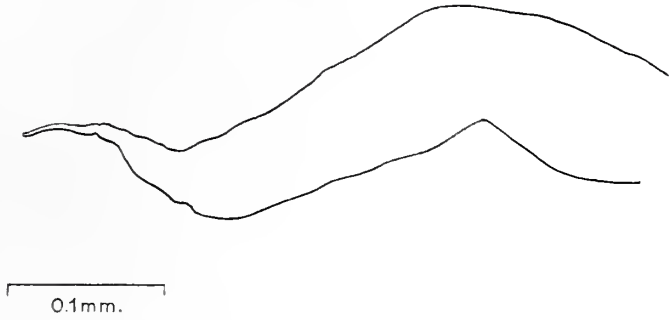
Text-fig. 17.—*Baccalaureus digitatus* sp. nov. Whole specimen to show the characters of the mantle. *l.p.*, lateral pouch. Other lettering as before.



Text-fig. 18.—*Baccalaureus digitatus* sp. nov. Segmented body from the right-hand side. *l.app.*, lateral appendage. Other lettering as before.

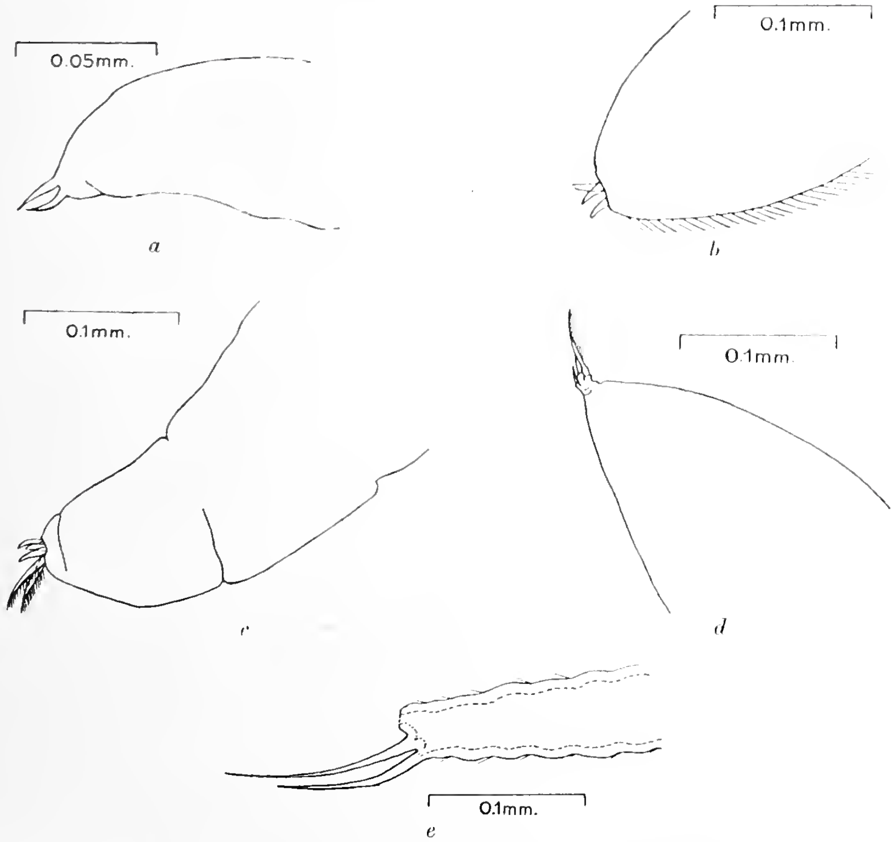
(Text-fig. 19; it is not shown in Text-fig. 18). It ends in a single, spine-like process. In this specimen it was possible to trace this appendage forwards nearly to the anterior edge of the oral cone.

Thoracic appendages could be distinguished with certainty only on segments 3, 4 and 5 of the thorax. No appendage could be found on segment 6. These appendages are



TEXT-FIG. 19.—*Baccalaureus digitatus* sp. nov. 1st thoracic appendage (?) of the right-hand side.

broader than those of other species, and their terminal setæ are generally better developed. Thoracic appendage 3 (Text-fig. 20*b*) bears three short, stout setæ terminally, but thoracic



TEXT-FIG. 20.—*Baccalaureus digitatus* sp. nov. Thoracic appendages and caudal fork. *a*, Lateral appendage of the right-hand side. *b*, 3rd thoracic appendage; right-hand side. *c*, 4th thoracic appendage; right-hand side. *d*, 5th thoracic appendage; left-hand side. *e*, Caudal fork, upper ramus.

appendage 4 (Text-fig. 20*c*) has two longer setæ in addition. These longer setæ bear a row of short spines along one side. Thoracic appendage 5, similarly, has two longer, spinous setæ, but only one of the shorter type of seta could be distinguished.

There is also an appendage which lies at the side of the thorax, immediately above the chitinous ridge (Text-fig. 18, *l. app.*). It is also broad and lobe-like and ends in two stout spines (Text-fig. 20*a*). It resembles the posterior process which arises from the "antenna" in *B. japonicus* (p. 251), *B. argalicornis* (Brattström, 1936) and *B. torrensis* (Pyefinch, 1937), but in this case, although the base of this appendage was carefully examined, no trace of the plate-like structure, which occurs in the species mentioned above, could be seen. This appendage could be traced back only as far as the third thoracic segment (Text-fig. 18), but it seems unlikely that this point really represents its actual point of insertion. The homologies of this appendage thus are uncertain.

The lateral chitinous ridge stretches from the posterior edge of the first abdominal segment forwards to the anterior edge of the second thoracic segment, where it ends abruptly. Posteriorly it is broad and rather ill-defined, but anteriorly it becomes narrower and is then sharply distinct. Dorsal setæ occur on every thoracic segment, as well as on the first abdominal segment.

The abdomen is more normal in form and consists of four segments, the first segment bearing the broad penis mid-ventrally (Text-fig. 18, *pen.*). The rami of the caudal fork are normal in form, but their tips were unfortunately damaged in removing the body from the mantle. However it seems probable that each ramus has three terminal setæ and, judging from the widths of the bases of these setæ, it is probable that the dorsal seta was the longest (Text-fig. 20*e*).

In section, the wall of the mantle was similar in structure to that of other species of the genus and, as in other cases, the outer surface of the parasite was covered with a layer of host tissue. The mantle cavity was full of nauplii, measuring 0·64 mm. long by 0·42 mm. broad. All these nauplii appeared to be in the same stage of development and all were still enclosed within the vitelline membrane. As it was found impossible to remove this membrane without damage to the appendages of the nauplii, it was not possible to determine the arrangement of the setæ on these appendages.

Remarks.—The characteristic form of the mantle does not seem a sufficient reason for placing this specimen in a new genus, as in other respects (the form and characters of the segmented body) this specimen conforms to the diagnosis of the genus *Baccalaureus* (Pyefinch, 1937). Thus this specimen should be described as a new species of the genus *Baccalaureus*. The specific name "*digitatus*" is given with reference to the form of the mantle.

DISCUSSION.

In conclusion it is of interest to mention the geographical distribution, and briefly to discuss the status of the species detailed above. Since the description of *B. japonicus* from Japanese waters, several species of *Baccalaureus* have been described, some from the Indian Ocean, namely: *B. maldivensis* (Maldive Is.), *B. hexapus* (Maungmagam, Burma), *B. argalicornis* (Madagascar), and *B. torrensis* (Torres Straits). The present material has extended the known range of *B. japonicus* into the Indian Ocean, and has added three new species, *B. disparcaudatus*, *B. verrucosus* and *B. digitatus* to those already known from this region. The genus *Baccalaureus* would thus appear to be widely distributed throughout the Indian Ocean.

With regard to the general distribution of the Ascothoracica collected by the expedition, it is of interest to note that their general distribution follows that of other Cirripedes. Stubbings (1936), in his report on the Cirripedes, draws attention to the fact that Zanzibar and the Gulf of Aden are areas especially favourable for these Crustacea. All the Ascothoracica recorded come from these areas and the station mentioned by Stubbings (106, Zanzibar area) as being especially prolific contributed seven out of the eleven specimens of Ascothoracica which were found.

As has been pointed out previously (Pyefinch, 1934, 1936) the validity of specific distinctions within the genus *Baccalaureus* is a matter of some doubt as, since the complete life history is as yet unknown, what are now regarded as specific differences may merely be due to differences in age of the specimens examined. This suggestion implies that degenerative changes, *e. g.* loss of thoracic appendages, loss of segmentation of the thorax, may take place during adult life. The specimens collected by the Murray Expedition do not, unfortunately, help materially in the solution of this problem. Of the material described in this report, *B. digitatus* certainly seems distinct, and *B. verrucosus* also has many distinctive characters, but *B. disparcaudatus* presents many points of similarity with *B. japonicus*.

In the light of this suggestion of adult degeneration, the inconsistencies in the original descriptions of *B. japonicus* may be important. Details of the segmented body of these Ascothoracica are not always easy to distinguish, but these inconsistencies may indicate a considerable range of variation in the two groups of specimens examined by Broch and Yosii, variations possibly correlated with differing ages.

Thus, until the complete life history of one species of *Baccalaureus* has been fully worked out, the validity of the various species described must remain in some doubt..

Finally, it is interesting to note that these parasites may themselves harbour parasites. In two cases, once in one of the specimens of *B. japonicus* from Sta. 106, and again in one of the specimens of *B. disparcaudatus* from the same station, specimens of a parasitic Isopod were found within the cavities of the lateral mantle coils. Sac-like masses which may represent stages in the development of the female of this Isopod and smaller individuals, presumably the males, were found. A male specimen of the same parasite was also found attached to the outer surface of the mantle lobes of *B. verrucosus*. These hyperparasites, which will be more fully described in the report on the Isopoda of the expedition, are believed to be a new genus and species, belonging to the family *Cryptoniscidæ*.

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